PERIODICAL ROOM
GENERAL LIBRARY
UNIV. OF MICH

MAR 30

THE APRIL SCIENTIFIC MONTHLY

EDITED BY J. MCKEEN CATTELL

DEMOCRACY AND DEPRESSIONS. PROFESSOR WILLIAM B. MUNRO 291

THE SOCIAL SIGNIFICANCE OF AMERICAN PANICS. PROFESSOR ROBERT G. CALDWELL 298

EROSION ON UNCULTIVATED LANDS IN THE INTERMOUNTAIN REGION. C. L. FORSLING 311

A NUCLEAR CENTURY. PROFESSOR LESTER W. SHARP 322

THE APPALACHIAN TRAIL. BENTON MACKAYE 330

VARIABLE STARS. DR. L. V. ROBINSON 343

CYCLONES IN CONTINENTAL BATH TUBS. EVALD ANDERSON 351

WASHINGTON SETS A RIVER ON FIRE. DR. NORMAN J. HARRAR 353

SCIENCE SERVICE RADIO TALKS:

SOME RECENT ADVANCES IN MEDICINE AND PUBLIC HEALTH. DR. G. W. MCCOY 356

HUMAN VARIATIONS. DR. ADOLPH H. SCHULTZ 360

CROPS AND CIVILIZATIONS. DR. E. D. MERRILL 362

SIMPLIFYING OUR CALENDAR. DR. CHARLES F. MARVIN 366

THE AMPHIBIAN IN ART AND LITERATURE. DR. S. W. FROST 369

THE PROGRESS OF SCIENCE:

General A. W. Greely; Award of the Agassiz Medal to Dr. Bigelow; Dr. Cannon and the Draper Medal; Development of Water Power in Switzerland; Rubber from Rocks 377

THE SCIENCE PRESS

LANCASTER, PA.—GRAND CENTRAL TERMINAL, N. Y. CITY—GARRISON, N. Y.

Yearly Subscription $5.00 Single Copies 50 cents

NEW BOOKS OF SCIENTIFIC INTEREST

Zoology. F. E. CHIDESTER. xii + 581 pp. Illustrated. $3.75. The D. Van Nostrand Company.

This text was written as a general survey of modern zoology for use by college students and to serve as a reference book for biologists. The author has placed special emphasis on physiology, ecology and applied zoology.

Earthquake Damage and Earthquake Insurance. JOHN R. FREEMAN. xiii + 904 pp. Illustrated. $7.00. The McGraw-Hill Book Company.

A study of a rational basis for earthquake insurance and of engineering data for earthquake resisting construction, written by an engineer and not a seismologist. It is intended primarily for structural engineers, insurance executives and property owners.

Arabia Felix. BERTRAM THOMAS. xxix + 397 pp. Illustrated. $5.00. Charles Scribner's Sons.

A narrative of the author's experiences in crossing "the empty quarter" of the great desert of South Arabia. He describes the human inhabitants and their racial and linguistic characteristics, and also includes material of zoological and geological interest.

The Social Life of Monkeys and Apes. S. ZUCKERMAN. xii + 356 pp. Illustrated. $3.75. Harcourt, Brace & Company.

The study of the social life of the lower primates has been approached from the deterministic point of view of the physiologist. The author is anatomist to the Zoological Society of London.

The Rural Community. DWIGHT SANDERSON. x + 732 pp. Illustrated. $4.40. Ginn & Company.

This outline of study of a rural community is the natural history of a sociological group. The author describes the forces and principles which influence the formation, persistence and decline of various types of rural locality groups.

Mastery Units in Physics. CLIFFORD HOLLEY AND VERGIL G. LOHR. xvii + 700 pp. Illustrated. The J. B. Lippincott Company.

A high school text, organized on the "unit plan" and covering the essential principles of elementary physics. The book is divided into eleven parts, each one of which concerns itself with one phase of physics.

Purposive Behavior. EDWARD CHASE TOLMAN. xiv + 463 pp. Illustrated. $5.00. The Century Company.

After a brief introduction of his theoretical views, the author summarizes a series of investigations on the learning of rats, cats, monkeys, apes and men. Then he proceeds to develop his own theory which he calls "signgestalt" formation.

Our National Aviation Program. CHARLES L. LAWRENCE. xii + 208 pp. Aeronautical Chamber of Commerce in America.

In this book the president of the Aeronautical Chamber of Commerce analyzes the aviation situation as it is to-day in America. The book is based largely upon articles that have been published previously in aeronautical magazines.

Clinical Psychology. ROBERT A. BROTEMARKLE, editor. xxi + 409 pp. $3.50. University of Pennsylvania Press.

This book is an expression of appreciation of Lightner Witmer, written by a group of former students, friends and colleagues. The papers are divided under two main headings: the primary problems of clinical psychology, and contributions of clinical psychology to other fields.

America Faces the Future. CHARLES A. BEARD, editor. viii + 416 pp. $3.00. The Houghton-Mifflin Company.

This book is a collection of articles by recognized leaders and thinkers about the plans for America's economic future. The book is divided into the two parts: The New Intellectual and Moral Climate; Blue-Prints for a Planned Economy.

Children of a Star. JULIE C. KENLY. xi + 242 pp. Illustrated. $2.50. D. Appleton & Company.

An elementary book on natural history in semi-story form for children. It has chapters on the beginning of the earth and of life, and then devotes a single chapter to many of the forms of life in the water and on land.

The Genius of Louis Pasteur. PIERS COMPTON. ix + 361 pp. Illustrated. $4.50. The Macmillan Company.

The major portion of the book is given over to describing in detail the development of the important discoveries made by Louis Pasteur in the field of medicine, and their numerous benefits to mankind. It has been written in non-technical language.

Cancer: What Everyone Should Know About It. JAMES A. TOBEY. xxix + 323 pp. Illustrated. $3.00. Alfred A. Knopf.

A book on cancer written for the lay reader, treating of the nature and history of the disease as well as its treatment and prevention. It contains an introduction by Dr. Joseph Colt Bloodgood, of the Johns Hopkins University Medical School.

The Universe Unfolding. ROBERT H. BAKER. x + 140 pp. Illustrated. $1.00. The Williams & Wilkins Company.

A popular book in the field of astronomy written by a professor of astronomy at the University of Illinois forming the story of man's increasing comprehension of the universe around him. The material has been presented for the general reader.

THE SCIENTIFIC MONTHLY

APRIL, 1932

DEMOCRACY AND DEPRESSIONS[1]

By Dr. WILLIAM B. MUNRO

PROFESSOR OF HISTORY AND GOVERNMENT, CALIFORNIA INSTITUTE OF TECHNOLOGY

DEMOCRACY makes its poorest showing in emergencies. Its merits, such as they are, appear most clearly in times of peace and economic prosperity. In such eras the problem of keeping people satisfied with their government is never a serious one. Prosperity silences criticism. It constrains the voters to approve any kind of leadership or no leadership at all. But when a country stands with its back to the wall in wartime, or when its industrial system is in serious danger of collapse, then the shortcomings of democracy as a governmental device become all too apparent, and a spirit of impatience spreads among the masses of the people.

Throughout the countries of Europe the democratic form of government has been losing its hold on the confidence of the people during the past ten years. Much of the popular enthusiasm for it, which surged forth at the close of the war, has now disappeared. It is being assaulted from the Left flank by Communism, and from the Right by Fascism. Save in Russia and in Italy, the foes of democratic government have not yet triumphed, but they are gaining ground in other countries. No one need be surprised to see Germany go Fascist or Spain go Communist if the economic situation which is giving rise to bitter discontent in these two countries is not alleviated. Even in England the traditional system of ministerial government has been severely jolted by a coalition cabinet which, in openly discarding the principle of solidarity, has made the government a house divided within itself. It is difficult to see how the British system of responsible executive rulership can permanently function under such an arrangement. Only in France, among all the leading countries of Europe, does the democratic structure stand unimpaired by the happenings of the past few years. France, however, is a republic with the spirit of an empire. And the economic stress has been less severe in France than elsewhere.

In the process of political evolution democracy is our latest form of government, but this does not mean that it is going to be our last. It is almost wholly a development of the past hundred years and largely a product of the past fifty. Even the most valiant among its early protagonists did not expect democracy to serve permanently as a scheme of rulership. Thomas Jefferson, for example, had no such expectations. Better, perhaps, than any other statesman of his time he saw the limitations as well as the merits of a government dominated by the desires of a great and varied populace. Hence his prediction

[1] Address of the retiring vice-president and chairman of Section L—Historical and Philological Sciences, American Association for the Advancement of Science, New Orleans, December 31, 1931.

that as countries became industrialized, with large masses of people concentrated in the cities, the strain that would be put upon popular government might prove heavier than it could bear.

Jefferson was right in his interpretation of political history. He appreciated the fact that the form of government must be related to the conditions under which the people live, and that such conditions may undergo great changes in the course of a century. Accordingly, he warned his countrymen that they must stand prepared to reconstruct their political institutions from age to age, lest government lose touch with the aspirations of the people whose welfare it was designed to serve. Jefferson was a believer in the democratic form of government because he believed that it best served the requirements of his own day, a day of simple life in a land where virtually the whole people were wringing their livelihood from the soil, where industries were few and small, where there were no large cities and where for the first time in human history a measurable approach to economic equality had been achieved.

But it was not his conviction that a scheme of government based on the principle of mass control would prove effective in all ages and under all conditions. On the contrary, the writings of the great Virginian persistently urged that future generations should periodically reexamine the old dogmas and abandon those which time and circumstance had thrown out of consonance with the facts of national life. Serious harm has been done by the public imagination to various tenets of Jeffersonian philosophy by giving them a universal and eternal application, when they were intended to be of local and momentary relevance only. "This world," said Jefferson in one of his most significant but least-remembered aphorisms, "should always belong to the living generation and not to generations that are past and gone."

New popular governments replaced autocracy during the era between the French Revolution and the Treaty of Versailles, but autocracy did not weaken and fall because it was inherently unsound as a plan of government. During the long feudal régime it was the best and indeed the only effective form of rulership that could have been devised. For centuries the principal function of government was to defend and protect. National defense and the maintenance of order within the realm absorbed almost the sum total of governmental energies. Monarchs and territorial magnates ruled the land because they were the only ones able to muster the national strength in the oft-recurring emergencies.

Gradually, however, the protective work of government became relatively less important as the positive functions developed. Likewise the need for more revenue became imperative; the area of taxation widened; and the people who paid these taxes began to clamor for a share in the control of public policy. Government by the taxpayer thus replaced government by the divine right of kings. But government by the landowners and taxpayers did not mean democratic government in the present-day sense. It excluded from the suffrage a large proportion of the adult population. The doctrine that all men are entitled to a share in the control of their government, irrespective of their property or taxpaying status—that doctrine is the child of the great revolution which swept France near the close of the eighteenth century and presently sent its echoes throughout the whole western world.

Democracy in its present-day sense came in with the declaration of the rights of man and the vogue of an equalitarian philosophy. Based on the

postulate of human equality it requires for its successful operation an environment in which a fair approach to social and economic equality is realized. It also demands for its efficient functioning a condition of affairs in which the problems of public policy are sufficiently simple to be within the compass of the average mind. Both these requirements were fulfilled to a reasonable degree, in the United States and in Europe, during the larger part of the nineteenth century. The great issues of that century were mainly political, and such economic issues as arose were not complicated beyond the capacity of the average human understanding.

To-day all this has changed. Economics and politics have become hopelessly intertwined. There is almost no political issue nowadays that does not have great economic implications, and there is no economic issue that does not find itself enmeshed in the complications of politics. People do not realize how enormously the functions of government have expanded during the past fifty years, and especially during the last quarter of a century. To-day the hand of government reaches into every nook and corner of the world's economic activity. By the erection of tariff barriers it dislocates the ordinary channels of international trade. By systems of taxation it can promote or throttle the industrial capacity of the people. By its control of banking and currency and credit it has power to raise or lower the general level of prices. By its network of regulatory laws and ordinances every great government likewise controls transportation and communication, sometimes in a measure which virtually amounts to public ownership. And the vast spread of social insurance, especially insurance against unemployment, has brought in its train a series of economic problems which the governments of European countries seem utterly unable to solve.

The day of rugged individualism and laissez-faire, in a word, is gone and probably gone forever. Democracy came in with the philosophy of hands-off; it linked itself with the proposition that a government is best when it governs least. To-day this proposition has given way to the doctrine that there is nothing which a government should not do if it can do the work better than it would otherwise be done. One would have no fault to find with that doctrine if governments were permitted to use expert judgment in dealing with the problems which come before them. But that is just what governments, democratically constituted, are not permitted to do. They must be guided by popular desire, whether it be judicious or not, for democracy rests on the principle, enunciated by Rousseau, that majorities are always right, even though by every pragmatic test they are proved to be wrong. The submission of complicated economic issues to great masses of semi-illiterate voters is merely referring the decision to the supreme court of ignorance. One may be pardoned for raising, in all seriousness, the query whether a world of steadily-increasing complexity in its human relations can be expected permanently to let its destinies be guided in that way.

Consider the troubles of mankind at the present hour. In larger measure than we realize they are the outcome of political ineptitude. The post-war treaties were framed, for the most part, on the formula of self-determination. Boundaries were redrawn to synchronize with racial groupings. Little or no attention was paid to the economic dislocations which this remapping of Europe was bound to involve. The treaty-makers, for example, set up a new Austria without giving it the eco-

nomic resources with which to maintain itself. Thereby they forced the Austrian government to seek a customs union with Germany and thus placed an almost insuperable blockade in the way of amicable Franco-German relations.

The new boundaries, as was natural, inspired an orgy of tariff-making which threw trade out of its older channels, cut off the markets for established industries, and forced new home industries into being. These infant industries, sheltered behind tariff walls, became heavy borrowers of capital and contracted obligations which their earning power does not enable them to liquidate. Thus was forged the chain of errors—new boundaries, new tariffs, new industries, new obligations and new bankruptcies.

Likewise the new democratic constitutions which were adopted by European countries at the close of the war had something to do with the accentuation of economic difficulties. Germany, Austria, Hungary, Poland, Czecho-Slovakia, Jugoslavia—one and all they hastened to equip themselves with the accoutrements of up-to-date democratic rulership, including universal suffrage, proportional representation, ministerial responsibility, initiative and referendum, bills of rights and local autonomy. Provision for proportional voting in these new constitutions was a particularly flagrant mistake. It meant the encouragement of party disintegration with government by blocs and consequent executive instability. Conditions in all European countries during the past ten years have called for stabilized, assertive leadership and for parliamentary support of the executive authorities. The new constitutions have virtually precluded either of these things.

The new democracy, moreover, brought with it a new social orientation. Political power passed quickly into the hands of those who wanted all manner of governmental paternalism for their own benefit. Under this political pressure the governments embarked on extensive programs of social amelioration, the costs of which were far beyond their means. Not being able to raise taxes proportionately, the budgets disclosed heavy deficits which had to be liquidated in ways that impaired the national credit and weakened public confidence in the banks. Even in England a feeling of financial insecurity spread widely because of the steady excess of expenditures over revenue—an excess due largely to the gigantic weekly outpouring of allowances to the unemployed which in turn was dictated by the political power of the universal suffrage voter.

This feeling of financial insecurity gave rise to the hoarding of gold and the flight of capital. Bank reserves were depleted at a rapid rate and foreign deposits were withdrawn from the banks in Austria, Germany and England. In Austria the country's largest banking institution closed its doors; Germany called for a moratorium; England went off the gold standard. The chain of events leading to these serious economic mishaps is rather tangled; but in the last analysis the primary cause is to be found in the orgy of unsound governmental financing, with wasteful public expenditures, badly unbalanced budgets, steadily recurring deficits and the imminent prospect of inflation as the only way out—all of which must be laid at the door of the New Democracy.

The United States has fared better than most of the European countries and chiefly because we have indulged in no such carnival of governmental extravagance. Our troubles are due in larger degree to the excesses of private enterprise. But there is no certain assurance that, during the next year or two, we may not be led by popular clamor into a repetition of Europe's

financial folly. Already there is a widespread demand that the national government shall proceed to restore prosperity by squandering the people's money on a large scale. No nation has ever achieved a restoration of prosperity in that way. The argument is, however, that no nation ever faced an economic crisis of such severity as that which the United States is now passing through.

Such an argument is not based upon the facts of history. The economic situation in the United States is bad enough at the present time, and it may grow worse; but it has not yet reached the point where it can be termed relatively more serious than any such occurrence in the past. A little less than a hundred years ago, for example, we had a major depression in the United States with many features similar to the present one. The era from 1829 to 1837 was marked by an orgy of speculation which had no parallel in the previous history of the country. The building of the Erie Canal and the Cumberland Road, together with the construction of many internal improvements, led to widespread speculation in land. New territories were opened up to more convenient communication, and people discounted the value of these lands far into the future. The speculation backwashed into the cities along the Atlantic seaboard and real estate values were inflated beyond all reason. The rise in land values was accompanied by a general rise in the level of commodity prices, particularly in the case of agricultural staples such as grain and cotton. This rise extended to manufactured products also, and imports from Europe were greatly increased during the period. Everybody went speculating. As most of the population were engaged in agriculture they naturally speculated in land.

This great inflation of values naturally affected the banks, which were called upon to provide the funds for purchases of land and commodities at the enhanced prices. The total circulation of all the banks in the United States was about forty-eight million dollars in 1829. Eight years later this had more than trebled and amounted to one hundred and fifty million dollars. Bank loans went a similar expansion. They totaled about one hundred and thirty-seven million in 1829 but rose to well over a half billion in 1837.

The panic of 1837 came quickly and was of great severity. Land values came tumbling down within a few weeks. The decline in values was in some cases as much as 80 per cent. The result was that banks all over the country found themselves solidly frozen and almost all of them had to close their doors. Just substitute common stocks for land and you have the collapse of paper-wealth in 1837 repeated in 1932. The similarity in some features is impressive. For example, after the first crop of bank failures there was much hoarding of currency. There was a very large deficit in the financial operations of the national government. In 1838 this deficit amounted to twelve million dollars, which was the largest ever encountered in time of peace down to that date.

In some respects the crisis of 1873 bears an even closer analogy to that which we are now experiencing. There was a primary recession immediately after the close of the Civil War, just as we had a similar phenomenon in 1921–22 almost immediately after the close of the World War. This primary setback was of short duration in both cases. In 1867 it was followed for a six-year period by an epoch of unprecedented expansion in American industry and transportation. This was the heyday of railroad building. Over thirty thousand miles of new railroads were built dur-

ing the six years between 1867 and 1873, the construction of these roads being stimulated by land grants and bonuses from states and municipalities.

This orgy of construction was financed by the issue of bonds and stocks in hitherto unheard-of amounts. A substantial proportion of these securities was sold abroad, more particularly in England, but much was absorbed by banks, by other financial institutions and by individuals in the United States. Soon these securities rose to values which were wholly out of line with the earnings which the railroads could possibly expect to make in any man's lifetime. The building of the railroads naturally stimulated various allied industries, such as iron mining and timber, so that the facilities for production in these industries were enlarged beyond all normal needs. Likewise the new transportation lines made agriculture more profitable because it enabled the farmer to market his products more readily, and this increased profitableness quickly led to the overproduction of grain. All in all, everything was made ready in 1872 for a general collapse.

The panic of 1873 was more than a panic. It was the beginning of a rather prolonged period in which all values kept slipping downward. Security prices took the first plunge, followed closely by real estate values. Wholesale prices quickly joined the retreat; then retail prices had their inning, and wages went down last of all. In fact retail prices and wages were still going down when securities, land values and even wholesale prices had begun to move up again.

The first indications of a turn during a depression make themselves apparent in a hardening of certain wholesale prices. The rise begins with consumer's goods, that is, with staple commodities like wheat, corn and cotton which are rapidly used up. This is followed by a stabilizing of wholesale prices in commodities of greater longevity, such as steel, copper, rubber, lumber and leather. Meanwhile, security prices respond to the earliest of these omens; hence it usually happens that securities start upwards and proceed a considerable distance, while the income from these same securities is still going down. This is quite likely to be the case during the next few years. Investors must not expect to see their dividends put back to the old figures for some time; on the other hand, the capital value of their investments may double or even treble within a relatively short period. This is because security values reflect the prospects of earnings rather than the actualities. Accordingly we must look for a reduced yield from the federal income tax, even though the rates be considerably increased.

Our most immediate danger in the United States is that we may repeat, at the present juncture, the folly of European countries by failing to cut governmental expenses, by borrowing to cover deficits and by using the public credit wastefully. Already there is being put upon Congress and the state legislatures strong pressure to embark on such a course. The national finances for 1931–32 will show a formidable deficit, perhaps the largest that the United States has ever had in a year of peace. For 1932–33 the budget of the United States can only be balanced by a drastic cutting of public expenditures as well as by far-reaching increases in taxation. Will the American democracy show the good sense and courage to adopt these measures, or will it be drawn into the vortex of unsound public financing as European democracies have been?

Meanwhile the events of the past ten years ought to convince the world that economic laws and forces are just as inexorable as the laws of nature. One of

these is the proposition that extremes generate their opposites. Where there are peaks there must be valleys. That is just as true in economics as in geography. Nevertheless each successive generation of men insists on producing an era of artificial prosperity followed by an interlude of violent reaction. So whether our present troubles clear up quickly or endure for several years there is one prediction which can be made with absolute certainty, *viz.*, that after the American people have evolved from their present cycle they will proceed to run the same course all over again.

Our great-grandfathers delivered the panic of 1837; our grandfathers went them one better in 1873; our fathers repeated the trick in 1893; and we have managed, somewhat tardily, to follow their example with our present-day mess. Unless all history has been written falsely and all psychology is unsound, our children will achieve a first-class financial depression somewhere in the fifties, and our grandchildren will see that still another one is forthcoming before the twentieth century reaches its close. It is an amazing thing that man's control over nature has become so nearly complete during the past hundred years, and yet his control over relations with his fellow-men, particularly his economic relations, has not been conspicuously improved.

In Europe the general impatience with democratic institutions is more pronounced to-day than it has been at any previous time within human memory. Hence, if democracy is to be saved, the United States will have to do it, and the next couple of years will show whether we are equal to the task. The rescue will not be accomplished by cancelling Europe's indebtedness or by lending new funds to the Old Continent, but rather by putting our own house in order—by trimming public expenditures, by increasing public revenues in ways which will not unduly increase the burden on industry, by refusing to be drawn into extravagant schemes of social welfare which in the end react to the disadvantage of those whom they are designed to help, and by restoring public confidence in the country's institutions of credit. In a word, democracy can be preserved by demonstrating that at least one democratic country can keep its head.

THE SOCIAL SIGNIFICANCE OF AMERICAN PANICS[1]

By Professor ROBERT G. CALDWELL
RICE INSTITUTE

A PROMINENT American banker, whose name is found frequently in the public press, has recently remarked that the experience through which America has been passing since the severe financial panic in October, 1929, is both unprecedented and unusual. Unfortunately, of course, depressions, panics and wars have alike punctuated human history, and our present experience, far from being either unprecedented or unusual, has in all its fundamental features been matched by that of every generation of Americans. Indeed, it is tempting to go, with Ferrero, much further back to a civilization so curiously like our own and to the great depression in the third century of the Christian era, which in the judgment of at least one brilliant historian paved the way for the fall of the Roman empire. The student of economic similarities might even find materials in the Egypt of the Pharaohs and in the seven fat years and the seven lean years of the book of Genesis. But though we read of long depressions with momentous social consequences among the Chinese, the Babylonians, the Assyrians, the Greeks, the Romans and the people of medieval Europe, only one business cycle in all recorded history seems to have had a Joseph, wise or lucky, and able to prepare in the fat years for the lean years which lay ahead.

One common feature of all these early depressions is their length, perhaps because those that lasted a mere seven years seem across the vista of the years too brief to be worth remembering. Among other periods of fifty or a hundred years, there have been historians to suggest that even the two hundred years of the crusades are to be explained in part by the practical necessities of a very long economic depression. Face to face with over-production and unemployment in the most lucrative trade of the age, the knights and soldiers who took service under the banner of the cross may have been actuated by motives not unlike those that in a later age brought the dole to England and the community chest and other temporary forms of relief to the hard-pressed America of our own day. Each time, too, in other centuries, as men have passed through periods of depression, they seem, at least sometimes, to have learned the lessons that adversity enforces, and have at length, soon or late, escaped by new methods of government, by the adoption of new business institutions better suited to the times in which they lived. From their own point of view, each generation seems thus to have found at last an opportunity to rise on stepping stones of its dead self to higher things.

But be these more remote examples as they may, one needs to go no further back than the beginnings of the seventeenth century and to the founding of America for the certain records of a people whose history has been marked in each generation and at every crisis by a very serious and sometimes long-continued depression. At the very threshold we find more than a little evidence that the fundamental and persistent cause of that astonishing movement of population that Woodrow Wilson

[1] An address given at the eighty-ninth meeting of the American Association for the Advancement of Science on December 31, 1931.

called the swarming of the English was the hard necessity of poverty. The enclosure of the fields of the English peasant and the decay of the ancient guilds were of course not new, but their full effects were only visible in the closing days of Elizabeth and in the reign of her successor. Even in the early sixteenth century Sr. Thomas More had written burning words regarding the difficulties of the unemployed. More than once he had seen husbandmen compelled to sell their little homes and "depart away, poor innocent wretches, goods, men, women, husbands, wives, fatherless children, widowes, woeful mothers and their young babes . . . out of their known and accustomed houses, finding no place to rest in. And when they have wandered abroad . . . what can they else do but steal . . . or go about begging? And then also they be cast in prison as vagabonds, because they go about and work not, whom no man will set to work." How often in later days, would the same description prove to apply!

Fifty years later conditions were worse, rather than better. Many thoughtful Englishmen now pointed out the possibility of finding a solution for prevalent unemployment by a consciously directed policy of colonial expansion. Thus Sir Humphrey Gilbert, who was to give his life to the enterprise that he advocated, wrote in 1574: "We might inhabit some part of these Countreyes (America) and settle there these needy people of our country which now trouble the Commonwealth and through want here at home are enforced to commit outrageous offences whereby they are daily consummed with the gallows." In 1611, four years after the first settlement of Virginia, the watchful Spanish ambassador, Velasco, wrote to his master: "Their principal reason for colonizing these parts is to give an outlet to so many idle wretched people as they have in England, and thus prevent the dangers that might be feared of them." It is noteworthy that the decade of most severe depression came from 1620 to 1630, a time in which the foundations were laid for more than one future American state.

The earliest of purely American panics came to the various colonies, especially the tobacco regions of Virginia and Maryland, during the reign of Charles the Second. The number of people living in America was, of course, a mere handful, but the sequence of events was strikingly similar to that of a later age in the complicated industrial and banking community. A period of great prosperity, in which the price of tobacco had been high, trade active and the plantation system constantly fed by new importations of indentured servants, was succeeded by very hard times in which tobacco became a mere drug on the market. As usual, these difficulties pressed with great force on the recently established western farmers, some of whom had been indentured servants on the larger plantations of the wealthy men of the tidewater region. The results, as every one knows, were highly dramatic; for the western men in deep distress blamed their chief difficulties on the selfish policy of the aristocratic governor, Sir William Berkeley, and the group of favorites that surrounded him. By a curious coincidence in dates, just one hundred years before the declaration of American independence, which had in some respects a similar social as well as a political significance, the common people found a leader in a young planter named Nathaniel Bacon, a relative of the renowned Lord Chancellor of England. With the assistance of two friends, the Scotchman, William Drummond and "the thoughtful Mr. Lawrence," as he was called by his neighbors, and under the pretense of defending the colony against the Indians, Bacon raised the standard of revolt, gained some initial successes, compelled

the governor to accept far-reaching democratic changes in the government of the colony, and proved his power by capturing the seat of government at Jamestown and burning the houses of that center of conservative control. But Bacon and his friends were ahead of their day, and the death of their leader left the discontented rabble unable to cope with the prestige of the wealthy planters under the banner of legitimate authority. A movement of great significance, which had had reverberations in places as distant as North Carolina and Maryland, suddenly collapsed. Bacon was dead, the dour Drummond was soon captured to meet the fate of traitors, and the thoughtful Richard Lawrence barely escaped into the wilderness where perhaps under some new name he was able to take up again the career that he had left behind.

The results of this episode were probably more permanent and significant than the hard fate of the leaders would lead one to suppose; but when the early chroniclers looked for the causes of a great depression and of the revolt which came from it, in typical seventeenth century fashion they selected features in the general situation which were unique rather than those that suggested a common experience in the history of such revolts. Thus a sober and detailed story of these events, the one to which historians have been chiefly indebted, commences at once and boldly by a type of explanation as much in fashion in those distant times as the theories of the business cycle are to-day:

> About the year 1675 [writes the planter whose initials are appended to this document] Appear's three Prodigies in that country, from which th' attending Disasters, were looked upon as Ominous Presages. The one was a large Comet every evening for a week or more, at Southwest; thirty five degrees high, streaming like a horse taile westwards, until it reached almost the horizon, and setting towards the northwest. Another was flights of pigeons, in breadth nigh a quarter of the mid-hemisphere, and of their length was no visible length; whose weights brake down the limbs of large trees whereon these rested at nights, of which the Fowlers shot abundance and Eat 'em. This sight put the old planters under the more portentous apprehensions, because the like was seen (as they said) in the year 1640 when the Indians committed the last massacre, but not after, untill that present year 1675. The third strange appearance was swarms of Flyes about an inch long, and big as the top of a man's little finger, rising out of spigot holes in the earth, which eat the new sprouted leaves from the tops of the trees without other harm, and in a month left us.

And after this remarkable introduction, the truthful Thomas Mathew, for such was probably the author's name, continued with evident impartiality to recount the events of the next two years in the old colony of Virginia.

For the purposes of this brief review, passing over other depressions of the colonial period, of which the one in 1764 was the most notable, America had barely escaped from the political and military dangers of the period of the Revolution when she was face to face with the first of the panics of the national period. As is now well known, the hardships of the war had been largely limited to the tattered soldiers of Washington and Greene and to those communities which had been the scene of bitter civil contests between the patriots and the loyalists. In other places, money had never been so abundant, for both the British and the French had war chests and distributed gold and silver, in the colonial period almost unknown, with what seemed at the time prolific hands. Especially in the neighborhood of the seaports where the foreign soldiers were established the farmers found a ready market for their crops and even the artisans were working hopefully under the influence of high wages. The inflation of the monetary medium, due to the large issues of Continental bills and of local forms of paper money, increased prices as if by magic, and made it comparatively easy for the debtor to meet his obligations. Such prosperity in many

places helps in part to account for the patience with which the American people endured the disadvantages of so long and so uncertain a contest. In New England, it is true, the old trade routes to the West Indies were no longer safe, the fisheries on which so many had depended for a livelihood were closed, and the whaling ships remained for years at their wharves in Nantucket. But war brought new opportunities and enterprising shipmasters laid the foundations of new fortunes by engaging in the adventures of privateering. The fictitious prosperity of the war years led to speculations in lands and to the investment of profits in shops for the manufacture of commodities that had once been furnished by the mother country.

When the war was over, conditions changed so quickly that many persons who had counted on the continuance of good times found themselves in sudden difficulties. The prohibitions of the European mercantile systems were now made general and permanent. Imports destroyed the prosperity of more than one little factory. Gold and silver left the country in payment for luxuries, and prices generally dropped with alarming rapidity. The conditions which had existed in Virginia one hundred years before on a small scale were now repeated on a continental scale. What seemed the harsh exactions of the creditors produced demands for paper money and other means for the relief of debtors, precisely parallel to the remedies that were later to be lumped together under the name of populism. From the point of view of the conservative classes, whose leaders were bound together by a consciousness of kind, the dangers of the times were merely emphasized by Shay's rebellion of 1786, put down in the dead of winter at the private expense of the great merchants of Boston. And there can be little doubt that the meeting of the constitutional convention which established a strong government capable of dealing with the dangerous excesses of democracy was hastened and made possible by the fears which the events of the great depression had made so clear. New trade routes were now opened across the Pacific to Asia, and the dangerous and discontented were drained away to the opening West, where they were to modify their institutions and to inaugurate the middle period in American history.

Before the next depression, the generation that remembered the troubles of 1786 had passed away. An era of speculation followed the close of the Napoleonic wars. In America this took the form of a great land boom. Great areas were bought on credit, and pretentious towns were laid out in regions that were to remain for many years thinly inhabited. Then came the crash. Staple productions fell to less than half their former price; land values declined 50 to 70 per cent.; manufacturers were in distress; laborers were out of work, merchants were ruined. In Cincinnati, whose condition was typical, by the foreclosure of mortgages, the national bank came to own a large part of the city—hotels, coffee-houses, warehouses, stables, iron-foundries, residences and vacant lots. Throughout the West and South, the bank became known familiarly as "the Monster." Out of the panic of 1819 came consequences no less momentous than those of thirty years before. Among these were the rise of political consciousness on the part of men who had previously been quite willing to let their betters do their thinking for them, growing demands for a more liberal suffrage, for the abolition of debtors' prisons, and above all for the division of the public lands of the West in smaller units and on more favorable terms. Instead of the minimum of 640 acres that had been proposed by the aristocratic Hamilton, good land could now be bought in farms of only eighty acres and for as little as one dollar and twenty-five cents an acre.

As in the case of the earlier depressions, 1676, 1764, 1786, the most marked consequence was a new movement into the West, in which broken business men and discouraged debtors were in the van. Even the vast reaches of the Middle West, where so much of the land had fallen into the hands of speculators, did not prove to be sufficient to satisfy the longing for escape which had been so common a feature of the great American depressions. Moses Austin, an enterprising Yankee, who had been engaged in the iron business first in Virginia and then in Missouri, found himself hopelessly involved in the meshes of the great panic. Without despairing, he decided to give up his citizenship and gained a grant of land in distant Texas where under the banner of Spain he might carve out for himself a new career. He did not live to carry out his plan, and it was left for his abler and less visionary son to become the founder of a new commonwealth. And not the leaders only. For history again repeated itself, and no one can study the records of the early settlers in Texas without being impressed with the extent to which they came to avoid adversity, just as their forefathers had once served a hard period of indenture in the old days in Virginia.

Our editorial writers who speak of the panic of 1929 as one of unusual severity and significance have surely forgotten 1819 and have certainly overlooked 1837. For in that year the story was much the same, except that this time there was no war, and that speculation had taken the unusually unfortunate form of canal building at a time when every month made it clear that the canal was doomed in competition with the steamboat on the rivers and especially the now rising railroads. Consider the fact that not some of the banks in the United States, but that every one closed its doors to its creditors and refused to meet its obligations in specie, that the burden of hopeless debts was so heavy that a reluctant Congress was compelled to pass a general bankruptcy law by which thousands of distressed debtors were relieved from their obligations, that six states behind the bulwarks of the eleventh amendment were so involved that they repudiated their public debts either in whole or in part, and that of these debts eleven millions have never been made good until this day, and we have a few hints of the seemingly measureless calamity that had overtaken a nation that only one year before had been riding high on the crest of a wave of rising prosperity.

Against the sufferings of 1837 our recent experiences seem minor and insignificant. Captain Marryat, the English novelist, reached New York in the midst of the panic and has left a vivid description of his experiences:

> Two hundred and fifty houses have already failed, and no one knows where it is to end. Suspicion, fear and misfortune have taken possession of the city. Had I not been aware of the cause, I should have imagined that the plague was raging. . . . Not a smile on one countenance among the crowd who pass and repass; hurried steps, careworn faces, rapid exchanges of salutation, or hasty communication of anticipated ruin before the sun goes down. Here two or three are gathered together on one side, whispering or watching that they are not overheard; there a solitary, with his arms folded and his hat slouched, brooding over departed affluence. Mechanics thrown out of employment, are pacing up and down with the air of famished wolves. The violent shock has been communicated, like that of electricity, through the country to a distance of hundreds of miles. Canals, railroads and all public works have been discontinued, and the Irish emigrant leans against his shanty, with his spade in his hand, and starves as his thoughts wander back to his own Emerald Isle.

For the first time in the panic of 1837, we begin to have definite statistical proof of the severity of the sufferings of the individual as marked by the figures both for suicide and by the number of convictions for crimes. With abundant resources, in an empty continent, America

was passing through an experience like that of seemingly overcrowded England in the days when Sir Thomas More wrote his "Utopia," and the social incidents differ only in the details of the time and the place.

Pass on twenty years, this time, through a period of great prosperity, in which America becomes the granary of the world and the haven of the starving and the distressed. If the panic of 1819 may be called our great land panic, and that of 1837 the canal panic *par excellence*, that of 1857 was surely the first of our two great railroad panics. Consider an editorial from *Harper's Weekly* for October 10, 1857, which sounds as if it were written yesterday:

> It is a gloomy moment in history. Not for many years—not in the life time of most men who read this paper—has there been so much grave and deep apprehension; never has the future seemed so incalculable as at this time. In our country there is universal commercial prostration and panic, and thousands of our poorest citizens are turned out against the approaching winter without employment and without the prospect of it.
>
> In France the political cauldron seethes and bubbles with uncertainty; Russia hangs, as usual, like a cloud, dark and silent, upon the horizon of Europe; while all the energies, resources and influence of the British empire are sorely tried, and are yet to be tried more sorely, in coping with the vast and deadly Indian insurrection, and with its disturbed relations in China. Of our own troubles no man can see the end. They are fortunately, as yet mainly commercial; and if we are only to lose money, and by painful poverty to be taught wisdom—the wisdom of honor, of faith, of sympathy and charity—no man need seriously to despair. And yet the very haste to be rich, which is the occasion of this widespread calamity, has also tended to destroy the moral forces with which we are to resist and subdue the calamity.

Wise words, which, if they could be remembered by more than a single generation of men, might go far to prevent the next catastrophe!

But the very next experience of the kind came in a shorter period than had been usual, and was probably hastened by an increase of the spirit of extravagance and corruption which seems to be the inevitable consequence of every long war.

Of all our panics, this one which lies like a storm cloud across the years after 1873 has most points of likeness to our most recent depression. It came just eight and a half years after the conclusion of our most costly war; it began in Germany, which had a panic at almost the same moment as the United States, and from central Europe spread to France and Belgium and thence to England and all parts of the world. Everywhere currency inflation, with rising prices, wages and speculation, made itself conspicuous, and provoked a sharp reaction. Some panics have come out of a clear sky with unexpected suddenness, but in the America of the seventies cautious observers had expressed a fear that the currency was too much inflated, that the railways were being overbuilt, that there was overtrading, and habits of luxury and extravagance were apparent in the expenditures of individuals and in the rising budgets of cities and corporations. In the spring of 1873 the money market was so badly shaken that some of the close friends of the eminent financial wizard, Jay Cooke, begged him not to carry forward a syndicate to build yet another unneeded railroad across the plains. Throughout the first half of the year, the revelations in the Credit Mobilier scandals proved to the most unwary the manifold waste that was involved in the use of public funds for private enterprises, and scandals in the field of railroad promotion were matched in the business of banking and insurance.

The crash came in September, the most dramatic incident being the failure of Jay Cooke and Company, which had been regarded as a very pillar of financial stability. The public was still incredulous, and a newsboy, shouting, "Extra, all about the failure of Jay Cooke," was arrested by a horrified

policeman, who still felt it was the duty of the patriotic to whistle against the rising storm.

The panic, like all others, spread in widening circles and involved many who had no part in the era of corruption and speculation that had preceded. The building of railroads was suspended for lack of funds, giving an adventitious importance to unexpected terminals which soon became the rendezvous of the cattle drivers and gained the temporary eminence of the cow towns. Rolling mills, machine shops, foundries and other industries connected with rail transportation were closed for lack of orders, and as the winter approached laborers to the number of hundreds of thousands were thrown out of work. In the cold weather of 1874–5, long bread lines and demands for outdoor and indoor relief were common features of the life in great cities. Despite an abundant harvest, cases of actual starvation were not uncommon. Two years later, conditions had failed to improve, and the newspapers were devoting editorials to the "tramp-evil." From all over the East came reports of thefts, incendiary fires, rapes and even murders committed by vagrants. In some New England towns people on the outskirts were compelled to abandon their homes and in Massachusetts alone there were said to be a thousand vagabonds roaming the rural communities. Two hundred desperate tramps invaded a village in central Illlinois, and were only repulsed after a bloody encounter with the marshal and his constables. No one at the time regarded it as a function of government to bring any remedies to bear on a desperate situation. One statesman, James A. Garfield, said that it was no part of the business of government to find jobs for the unemployed. And this sentiment was widely applauded. In these circumstances, the American people found their own remedy in enforced economy. In the first year after the beginning of the panic the consumption of silks and other luxuries was decreased by more than four hundred millions. But even economy was no panacea, and the skies remained dark until the summer of 1878, almost five years after the commencement of the panic, when crop failures in other parts of the world created a new demand for American products, factories began to open, and life to return again to its normal channels.

The end of the reconstruction experiment in the South, the rise of agrarian power and discontent in the West, the introduction of windmills and barbed wire into the plains of the great West, the temporary supremacy of the cow towns at the end of unfinished railroads were unforeseen contributions of a great panic to the social history of the nation.

The story of our three last panics is too familiar to need recounting. In one respect they belong to a different cycle. For the cities rather than the West have become the true American frontier, and the movements of population which always follow a panic take a different direction. But the incidents again sound strangely similar, and in each case, in 1893, in 1907, and now in 1929, it is apparent that the nation has again stood at the crossroads of social and political change. We are somewhat too close to these events to be able to estimate their significance. But a few consequences are almost too obvious to require comment. Thus out of the tribulations and uncertainties of the nineties came the relative stability of the gold standard as established in the act of 1900. Similarly, the reform of the banking system in the Federal Reserve Act of 1913 can be traced directly to lessons learned in the panic of 1907. However gravely we may differ in our theory of the causes of panics, their social consequences have been both similar and momentous. Indeed, from the point of view of morals and of institutions, the periods of pros-

perity often appear in perspective relatively static and hopeless; and with all the sufferings which are incident to periods of depression, it is from these events that we are able to trace the process by which injustice has been lessened, ideals aroused and progress made possible.

Thus from the first tobacco planter in Virginia to the industrial and financial leaders of our own day, even when we leave out of account the minor rise and fall of the business cycle, no man has been active in the industrial or business life of his own time for as much as thirty years, without having the opportunity of at least one period of great and unusual prosperity and similarly passing through the gloom and the darkness of one depression. Curiously enough, if you consider spacing of these depressions, they seem to fall sufficiently far apart to make it unlikely that any single business man in the period of an active life of average length will ever be lucky enough to pass through more than one of these unusual periods of prosperity or unfortunate enough to have to meet more than once the oft-repeated problems of more than a single general depression. Accordingly, the individual who gets through with his panic early seems to be in a singularly fortunate position, and can hope with some slight confidence that the next major depression will fall in the life of his successor. On the other hand, the person who meets the crushing force of a depression in the later years of middle life, has more than once found the remaining years all too short to overcome the sudden disadvantages which have been imposed.

In all the abundant literature which has arisen from these depressions no one seems to have suggested the most obvious explanation that something may be due to the capacity of each generation of men to learn something from their own experiences and to guard against mistakes which events have made all too clear. From the superficial view of the historian, at least, there is more than one indication that men have often understood at the time, just as clearly as we can point out to-day, the fundamental causes of their own misfortunes, and that the generation of planters or bankers or stock brokers which has just passed through one of these oft-repeated human experiences is apt for a time to be fortified against similar dangers. So the persons who have lived through one great war are surely likely to handle the dynamite of international animosities with peculiar caution. But time is long and memory brief, and neither the diplomat nor the business man is skilful in using history, the long memory of the human race, as an aid to the recognition of old dangers under strange new forms, and so, in answer to the insistent demands of human greed or human ambition, twenty or at the most thirty years suffice to wipe out all effective memories, to clothe the hideous details of the last war in the attractive illusions of a glorious adventure and to make of the thoughtless cult of prosperity something of a passionate dogma against which even the boldest may not stand with impunity. In the meantime, often, the institutions in business or in government, which were designed to prevent the recurrence of similar evils in the future, have sometimes reached maturity and have begun to decay without prompt recognition of changed circumstances. Similar forgetfulness and institutional decay may, perhaps, in a larger philosophical view, help to account for the curious rhythm in these phenomena. If so, it may not seem strange that each generation has had to face its major war and likewise its major panic, and that the length of time between two of these occurrences is roughly similar.

The earlier theories of panics by European writers, beginning with Sismondi in 1818, and varying from the determinism of Jevons with his sun spots to the

half-humorous individualism of Walter Bagehot, who suggested seventy years ago that panics might be prevented if only the Lord Chancellor could control the investments of rectors, grandmothers and other foolish people, have of course had their echoes in America. But the favorite explanations have always laid the chief blame on the relative scarcity or abundance of the monetary medium. Unfortunately, such theories do not seem to be especially helpful at the time, for while one group of contemporary writers blame all the evils of the period to a currency that is too abundant, others are quite certain that it is too scarce. In 1786, in 1819, in 1873 and in 1893, the remedies suggested for depression were as far apart as the two opposite financial theories of the cause. And while uncertainties as to the value of money have been a common feature of panics and depressions, they have been by no means universal, suggesting the possibility at least that the supposed cause is after all a symptom and that the real origins of these phenomena, even though they do not lie quite so deep as the meteorological theory would suggest, are somewhat more complex than the mere quality of the monetary medium would lead one to suppose. Certainly at the beginning of the present depression there was little uncertainty as to the stability of the gold standard and the level of prices did not show that marked inflation which would account for the length or the severity of the depression. It is accordingly unlikely that similar experiences can be avoided, though they may be mitigated, by regulating the mere quantity and value of the general monetary medium. The passage of the gold act of 1900 was hailed by a paean of praise in the great New York dailies, and one went so far as to describe the act as one that was destined to end panics in America. Similarly, the experiences in the brief depression of 1907 were undoubtedly a motive of great force in producing important and far-reaching changes in the institution of banking culminating in the Federal Reserve Act of seven years later; and though the newspapers with even greater unanimity proclaimed the act to end panics, just as later the same journals saw the possibilities of a war to end war, we have now lived to the time when one great nation has avoided a depression by accepting a permanently depreciated currency, all the theories of stability to the contrary, and another in the very sink of bitter calamity has been compelled to abandon the gold standard at least for the time as the only possible escape from a hopeless financial dilemma. And the United States with abundant gold and a well-regulated system of national banking has escaped only in part the dangers of an almost universal situation. The explanation lies evidently somewhere else.

But in mentioning without seeking to analyze well-known general explanations of all panics, I had almost overlooked the astonishing similarities between the current explanations of the two chief groups of politicians at the time of each recurrent depression. One group, the one in power at the time, emphasizes always and in almost the same words, the universal and inescapable character of a depression against which no human wisdom could possibly have guarded, but from which with faith, courage, and especially by continuing to vote the right ticket the country may yet be delivered. Turn to the literature of 1837, 1857, 1893 and all the rest, and, if history does not repeat itself, the words of politicians often do; and you will at least discover the unconscious sources of the political addresses of next year. The views of the opposite group of political leaders suggest that while general causes had no minor part in the calamities which are so well known, the chief blame lies in the cowardice, the weakness and the folly of the party in

power. The truth as so often may perhaps be discovered half way between; for while there have been no cases of real world panics, and even in the worst some important countries have either by wisdom or good luck managed to escape, and while most panics, including the last, have in each country been made more terrible by the ineptness of statesmanship, no one in his senses, after the heat of passion has died down, would be apt to place the most obnoxious politician in any leading rôle. But while these contemporary theories, one impersonal and fatalistic, the other individualistic and personal in a highly concrete way, may have no scientific value, the historian can not overlook the fact that men have believed sincerely in the Jackson panic, the Buchanan panic, the Cleveland panic, the Roosevelt panic, the Wilson panic, and that even in these days of scientific enlightment, of which the meeting of this association is so eloquent a proof, if the phrase, the Hoover panic, is not yet familiar, it will undoubtedly come to life next year. The fatalism and the individualism of the politicians, while actuated by more obvious and immediate motives, carries the two groups no further apart than the fatalism and the individualism of the economists, and leaves the average layman, of whom the historian is necessarily an ignorant and eloquent example, stranded in a medley of alluring but unconvincing explanations.

The fatalistic view of panics, whether in its political or its economic phase, and it has both, is sometimes given special precision by the comparative nearness of some great war, and politicians and business men alike, whose deeds are in grave danger of being subjected to the pitiless analysis of the theory of individual responsibility, seize at once on so convenient and so hateful a scapegoat. And with much truth; for most men feel that in some half-realized way the waste, the extravagance, the moral decay which accompany a great war are connected with panics and depressions, some of which come many years later. So, even at the time, the panic of 1819 was readily explained, without any sharp effort at causal analysis, as the inevitable aftermath of the Napoleonic wars in which at the end America, of course, had become involved. This view was especially common among the New England Federalists, who had so bitterly opposed entrance into the war. Again in 1873, the explanation lay somewhat ready to hand, in the fierce struggle that had ended eight years before. A few contemporary economists have even attempted to make the connections more sharp and to account for the disturbing fact that in the most notable cases where panics and depressions have been causally connected with wars, the hard times in their most extreme form have ordinarily come so long after the deeds they are supposed to commemorate. From this point of view two panics follow every great war. The first, of which the depression of 1921 is an example, is called the primary depression and introduces a long period in which agriculture and the extractive industries generally, unduly stimulated by the needs of a wartime demand, find themselves face to face with reduced prices for wheat, cotton and other products. The result is an agricultural depression, which proves to be actually beneficial to the city dwellers, and leads to an over-expansion of industry, far beyond the possibilities of the impoverished but consuming farmer. Then comes the major or the secondary panic, some eight years later, in which country and city, agriculture and industry are at length involved in common though unforeseen calamity. A theory of primary and secondary panics, when tested historically, fits with reasonable accuracy the events after the Civil War, where a brief depression in 1866 was followed by a calamitous panic in 1873

and is again emphasized by recent history, where the depression of 1921 and that of 1929 follow at almost the same interval. But after other wars, the formula, in America at least, is no longer good. Thus after the Revolution, there was one great depression and not a pair, and again after the war of 1812, there was a single depression in 1819. But since in both cases America was still predominantly agricultural, these very exceptions may prove the rule. In other words, primary and secondary panics may be necessarily merged where the country has a simple form of economic life, either industrial or agricultural, to the exclusion of the other. All that one can say is that a country balanced between agriculture and industry has at least in America lasted too short a time to make such a precise theory capable of convincing proof, and the chances are that when the next war comes with its next cycle of panics economic conditions may have changed in so many and such unforeseen ways as to make necessary still another theory of the exact relation of wars to depressions. Nothing can illustrate better the fact that history is history and not economics and that there are limits to the inductive and historical approach to economic theory which no diligence is ever likely to overcome.

It might perhaps be possible to classify American panics as war panics and peace panics. For if we apply the simple logic of the method of agreement and difference, it is at once apparent that if we place 1764, 1786, 1819, 1873 and 1921 in the first category, there are others equally notable which lie in long periods of profound peace. To this group undoubtedly belong the severe depressions of 1837 and 1893. Conversely, if there have been panics without wars, there have been wars without panics. Thus the Mexican war, which for the times was sufficiently costly, was followed by no panic. Similarly, there have been historians to suggest that the buoyant optimism of the period of the Spanish American war, in which soldiers went to Cuba to the tune of "There'll be a hot time in the old town tonight," was at least in part a reaction against and a way of spiritual escape from the gloom and depression of the years which had preceded; but no one has argued that the brief rich men's panic of 1903 or the so-called Roosevelt panic of 1907 were in any sense primary or secondary depressions having any relation whatsoever to the military history of 1898. Indeed all the evidence seems to point to the conclusion that these depressions are to be explained by factors that were peculiar to the business conditions of their own time. Accordingly, no one would maintain that all wars cause panics and that all panics are caused by wars; so that if any general theory be possible, it must arise out of some common condition, frequently present in long periods of war, but which may with almost equal ease manifest itself in periods of profound peace.

Indeed the last illustration suggests another possibility. For if some wars are followed by almost inevitable panics, the reverse is equally true, and American history furnishes more than one illustration of cases where the circumstances of a panic have paved the way for war. Thus 1764 lies at the end of one war and at the origins of another. Most notably, the panic of 1857 fell with crushing force on the rising industries of the North and West and left the South untouched. Indeed, during the years of depression the price of cotton was unusually high and speculation in field hands went on at feverish pace. Accordingly, Northern communities which had usually voted the Democratic ticket became peculiarly susceptible to the arguments for high protective tariffs which Horace Greeley was spreading broadcast through the influential pages of the *Weekly Tribune*. The stage was

thus set for Republican victory in 1860. In the meantime, the continued prosperity of the South gave new meaning to the slogan that "Cotton is King" and made more than one planter deaf to the cautious arguments of such men as Alexander H. Stephens and Sam Houston. From this point of view, it is not improbable that the panic of 1857 had quite as much to do with secession and civil war as such dramatic incidents as John Brown's raid which once occupied so exclusively the attention of the historians of the war between the North and the South.

But the most obvious and superficial method of classifying American depressions is by their length. And this method may not be without suggestive possibilities. Thus the depressions may be sharp and brief, limited in area, and followed in a few months by renewed periods of prosperity. To this group would fall many minor depressions, for example, 1825, 1884, 1903 and 1914. Again, we seem to have a group of panics which have lasted approximately two years and of which the one in 1857 was undoubtedly the most notable. To a distinct class would fall the five years of depression that followed 1837, 1873 and 1893. Some one with great confidence in superficial historical analogies might even be found to argue that after two years of gloom the third year of a panic will be marked by flickering movements in the indices of prosperity, in which alternate despair succeeds to hope; that in the fourth year, the signs of returning prosperity are at once more numerous and more evident; and that the fifth year will come to benefit both the American people generally and those political groups which at the time are in a strategic position to capitalize the return of the full dinner pail. But experience has after all been too brief to tempt the cautious into the field of prophetic generalization. Under altered conditions, there seems to be no good reason why other categories of different length may not, and soon, be added to those which roughly describe the length of American depressions.

Conditions change so rapidly that it is unlikely that any theory of panics will be entirely satisfactory for more than a single decade. And yet, from even this cursory and unsatisfactory review of the chief American panics and depressions, different as they have been in many of their details, a few generalizations seem at least tentatively possible. In the first place, every panic of which we have any record has had as an antecedent condition a process of investment in lands, ships, goods, stocks, notes or other securities from which the investor has expected at least a return and often an unreasonable profit. Some of these investments have been virtually compulsory, as in cases where modern people have capitalized the very wastes and losses of great wars; again they have been obviously shortsighted, as in the case of the canals of the thirties and again in our own day in foreign investments in countries that were virtually prohibited by increasing tariffs from returning either principal or interest on their debts; others, still, have been marked by obvious elements of wasteful fraud, as in the case of the railroads of the seventies; and some finally have been ultimately wise and even socially beneficial, but have anticipated somewhat too eagerly the demands of a slowly rising population. But whether the investments have been compulsory, dishonest, absurd or even wise, the day of reckoning has come when the debtor has proved unable to pay, and the panic itself seems without exception to be the immediate result of the effort on the part of creditors to collect bad debts. For this reason one of the persistent features of panics has been an increased consciousness of kind among creditors and debtors alike, either individuals or nations, sometimes, as in Bacon's rebellion

and the uprising of Daniel Shays, leading to armed conflict and again, as in the march of Coxey's army, ending in complete fiasco. These depressions have usually been hastened and made more severe by elements of uncertainty in monetary systems, in tariffs or in diplomacy, to such an extent that in contemporary discussions these occasions of a panic have more than once come to occupy the center of the stage.

Now, if the causation of panics has been even roughly sketched, the other side of the equation is at least equally significant and has been too much neglected. For from these panics have come social consequences, using the phrase in its largest sense, which have not been entirely dissimilar. In America at least, one of these has been a large movement of population, like the westward movement of the early panics, and another has been the emergence from the conflict of the times of new and significant institutions, of which the Federal Reserve Act, the Independent Treasury System and even the Constitution of the United States may be regarded as examples. It is by these and other similar social consequences that the modern historical emphasis on these periods of depression is to be chiefly justified.

For, if bad investments and uncertainty have been the two common factors in the origination of panics, it is well to remember that no one of these has proved to be like the depressions of the ancient world either hopeless or without incidental advantages. In every American panic, the path of escape has been found in the very conditions of the depression itself. By the acceptance of the lower price level, by the removal of uncertainty, sometimes by the discovery of wider markets, where luck and foresight have both sometimes contributed, by enforced economy, by writing off bad debts, the foundations have been laid for still another period of prosperity.

The most discouraging feature of the whole story is that in the last experience, in spite of a well-organized banking system and of immense resources, both natural and acquired, in spite of all its vaunted business sagacity, with almost no accidents to furnish an excuse, America, by following at the same time two contradictory policies regarding her tariffs and her investments, has deliberately walked in a path which seemed to court inevitable disaster. The history of ancient and medieval panics is often a monument to human misfortune; that of modern panics, in which the last is surely no exception, are a supreme monument to human greed and to human folly. Let us trust that even this one will serve its function to arouse public opinion to unrecognized conditions, to change accepted formulas, and to introduce in both production and in foreign commerce methods which are suitable to a new age.

EROSION ON UNCULTIVATED LANDS IN THE INTERMOUNTAIN REGION

By C. L. FORSLING

DIRECTOR, INTERMOUNTAIN FOREST AND RANGE EXPERIMENT STATION, U. S. FOREST SERVICE

IT is a comparatively short time since the white man occupied the western half of the United States. Of this vast region only a limited area is, or probably ever will be, tilled. In contrast to the eastern and middle western states where the soil is used largely for the growing of cultivated crops, large parts of the West are now and perhaps always will be utilized principally as range land for the grazing of domestic live stock. Some of these lands have been grazed about 80 years, but most of them only about 40 to 50 years. During this relatively brief period, on account of our limited knowledge and due to the unhappy results of little managed grazing and unrestrained competition in the use of the open public lands and absence of fire suppression, there has been a marked depletion in the native plant cover and a consequent erosion of the soil on extensive areas. On the ability to recognize and correct this unfortunate situation depends much of the future welfare of the region, for once the soil is depleted by erosion generations may be necessary to restore its productivity.

The term "erosion" is here used to designate the washing away of soil at a materially more rapid rate than the constructive or restorative processes allow for soil accumulation and improvement. On steep slopes, never too well clothed with vegetation, there has always been a downward movement of the soil. Under normal undisturbed conditions such as prevailed before settlement this loss on most of the land was not in excess of the additions made to the soil by the processes of weathering and of the decay of plant materials. Had this not been the case, the slopes centuries ago would have been denuded to bedrock. The normal rate of geological erosion in most places was such that the constructive processes were equal to or slightly superior to the destructive. In other words, there was a balance in soil depth and quality established, which, except for subsequent abnormal erosion, would have produced a present soil condition somewhat better than that which occurred at the time of white occupation. Certain exceptions perhaps are the deeply dissected country of the Colorado River drainage and some other places where the normal geological erosion has been and still is enough more active to maintain unstable conditions. Present concern, however, is apart from the natural processes. It has to do with the areas where there is considerably accelerated removal of the better soil concurrent with fire and overgrazing during the past 40 to 80 years.

The Intermountain Region to which this discussion specifically refers, comprises all of Nevada and Utah, that three fourths of Idaho which lies south of the Salmon River, about one fourth of Wyoming west of the main chain of the Rockies, and Arizona north of the Grand Canyon. The major physiographic units are (1) the Great Basin occupied during the last glacial epoch by the prehistoric lakes Bonneville and Lahontan, (2) the area drained by the northern and western tributaries of the Colorado River, and (3) the Snake River drainage basin, together with the area

CHECK DAM IN MANTI CANYON, UTAH,
CONSTRUCTED TO CONTROL FLOODS AND DEBRIS FROM AN OVERGRAZED WATERSHED.

drained by the southern tributaries of the Salmon River.

Land Classification

The total land area is approximately 184½ million acres in extent. Of this only 3 per cent. is cultivated. Probably not to exceed 6 per cent. ever will be tilled on account of its limited water supply, its rough topography, or its shallow soils. Somewhat less than 11 per cent. is commercial timber land, of which one fourth, or a little less than 3 per cent. of the region is too dense for grazing. In other words, the Intermountain Region is predominantly a grazing territory, with comparatively small areas devoted exclusively to timber or to either irrigated or dry farm agriculture. However, about 10 or 11 per cent. is not grazed due to being waste, either barren or inaccessible. There is, therefore, approximately 139 million acres of strictly grazing land and 15 million acres of grazed timber land, which brings the grazed area up to about 154 million acres, or 84 per cent. of the whole.

Some of the most important watersheds in western United States lie in the mountains which fringe the intermountain plateaus. Although much more of the area is watershed from which flow temporary streams, some 30 million acres, or about 16 per cent., is properly classified as producing permanent streams. This area is made up approximately as follows: Five million acres of dense timber not grazed, 22 million acres of open timber and other range land, and 3 million acres that are protection forest or barren. Protecting this watershed land against erosion to maintain the quantity and quality of the water supply for irrigation and other use is a paramount problem in the region.

Not only is the region one primarily devoted to grazing, but the grazing industry is largely dependent on public lands. More than 75 per cent. of the whole region is still in federal ownership with at least another 10 per cent. state-owned. Of the federal land in the region, 100 million acres, or 54 per cent. of the whole, is open public domain.

This is approximately half of the entire uncontrolled public domain left in the United States. An additional approximately 10 million acres is federal mineral or other withdrawal with the surface right left to unrestricted free use. Another 29½ million acres is National Forest land.

Careful estimates placed the reduction in forage yield on the open public range during the 40 to 80 years of settlement at 50 per cent., or thereabouts. This figure is too high for some parts but in other areas there has been a destruction amounting to 75 to 90 per cent. During the quarter-century of administration by the Forest Service, there has been a 10 to 25 per cent. recovery on most of the National Forests, but the public domain has probably continued to decrease in productivity during this same period. On local areas of National Forest land where the soil was badly eroded prior to regulation there has been no improvement in forage production since control was inaugurated. Recent study has revealed that soil erosion is usually active under certain conditions on the loose granitic soils on some of the National Forests in Idaho. A series of general studies and three detailed investigations have shown destructive erosion to be wide-spread in the region.

Erosion Studies

Davis County, Utah, Watersheds

The summer just ended has pointedly called attention to present imminent danger of local floods accompanied by heavy erosion in Utah. In the general vicinity from Salt Lake City to Ogden, there occurred a series of over a dozen floods which cut great gullies in the hillsides and covered high-priced farming lands and highways with rock, gravel, sand and other débris from one to several feet in thickness. The soil on this watershed is largely sandy loam of mixed origin, having weathered from

EROSION DEPOSITS

AT THE MOUTH OF A SMALL STREAM TRIBUTARY TO THE ARROWROCK RESERVOIR, IDAHO. SEDIMENT TO DEPTH OF OVER 18 FEET HAS BEEN WASHED FROM THE OVERGRAZED SLOPES OF THE WATERSHED INTO THE RESERVOIR IN FIFTEEN YEARS OR LESS.

well-consolidated granite. It has moderate water-holding capacity and holds together moderately well.

The destructiveness of these floods resulted almost entirely from the soil, rocks and other débris eroded from the mountain sides and canyons. Numerous boulders, up to 300 tons in weight, were carried far out in front of the mouths of the canyons. Several dwelling houses were swept away or filled with earth and rocks, orchards on land worth $600 to $800 an acre were covered irreclaimably. It cost approximately $100,000 to open and repair the highways alone and finally the watersheds are left in such a condition that there is danger of repetition of the floods with every heavy summer shower of any magnitude. Similar mud-flows and floods occurred in 1923 for the first time since settlement of the region.

Meteorological records show that at fairly frequent intervals the summer rainfall is of a torrential or semi-torrential nature, as is true of arid regions as a whole. The rains of August 13, 1923, and of July, August and early September, 1930, were unusually torrential for the region. There is no reason, however, for assuming that equally heavy storms have not occurred many times during the last several thousand years, although there are no indications of equally frequent floods such as occurred in 1923 and 1930. At any rate, much more apparent reasons for the recent outbreak of floods are found in the depletion of the plant cover.

An examination of the mountain front which rises from an elevation of 4,800 to 9,000 feet in a distance of 4 miles, from which the water and débris came, clearly established that the floods originated on the denuded upper limits of the slopes. Gullies began where heavy overgrazing by sheep and cattle, along with occasional brush fires, had removed most of the plant cover. Groves of aspen had been stripped of their reproduction as high as sheep could reach. In comparatively large areas a few large specimens of sagebrush (*Artemisia tridentata*) and niggerhead (*Rudbeckia occidentalis*) were practically all the vegetation left. Since neither of these species can develop on poor soil, it is concluded that such areas had been well clothed with vegetation typical of similar sites not so abused. Gullies began in these denuded spots and concentrated in the natural ravines. In a typical case there was a gully starting near the drainage divide that had been washed to a depth of 25 feet within 200 yards of the summit, showing how quickly the water concentrated in denuded areas. Interspersed areas, covered with a dense stand of little grazed chapparal, or patches of grass-brush land inaccessible to live stock but otherwise similar in character to the denuded land, were not eroded and showed no indications of flashy run-off.

Farther down the mountain side on much steeper slopes, and on the slopes of the main canyons, there is a good covering of oak brush and other vegetation. No gullies led from such areas into the ravines. There were, however, a few small denuded spots resulting apparently from burns. The fact that gullies were washed on these nearly bare areas showed that the rainfall had been as heavy over the brush-covered slopes as on the denuded areas above.

The water and earth débris from the feeder gullies on the denuded land above once concentrated in the main canyons, poured through the oak zone. The canyon bottoms were gutted to a depth and width of 50 to 70 feet. When the floods reached the lower gradients at the mouths of the canyons, they spread across the benchland and out upon the valley farms with the results mentioned.

Detailed Erosion Area Studies

Since 1912, the research branch of the U. S. Forest Service has maintained at

BOULDERS UP TO 200 TONS IN WEIGHT

WERE TRANSPORTED LONG DISTANCES OUT IN FRONT OF THE MOUTHS OF STEEP CANYONS BY THE FLOODS OF 1930 IN UTAH. THE LARGEST BOULDER CARRIED BY THESE FLOODS, IN AN ADJACENT CANYON, WEIGHED APPROXIMATELY 300 TONS.

the Great Basin Branch Experiment Station on the Ephraim Canyon watershed of the Manti National Forest a detailed study of the relation of vegetative cover and grazing to surface run-off and erosion. This is in a locality 10,000 feet above sea-level, where the annual precipitation, more than two thirds of which is winter snow, is about 30 inches. Two somewhat equal drainage areas distinctly different in degree of plant cover were placed under control and the water led through covered settling tanks equipped for measuring the water and eroded material. Rain gauges on the two areas measure the rainfall from each summer storm, and in later years tipping-bucket gauge records have been obtained to determine the rate of fall as well as the amount. The two watersheds, 882 feet apart, are subject to the same climatic influences.

The soils of both areas originated from limestone and shale. The raw unweathered soil is fine-particled, very adhesive when wet and having a granular-fragmental structure when dry. Where undisturbed, as on most of the well-vegetated area, designated as B, the surface soil is dark-colored and rich in organic matter to a depth of 3 to 6 inches. Beneath this is a layer of from 4 to 12 inches of friable clay fairly rich in organic matter and plant food. The second area, designated as A, was considerably eroded when the study began and has since been further eroded. On the latter plot the two upper layers of soil had been eroded to such an extent as to expose a raw inert clay low in organic matter and plant nutrients and very favorable to rapid run-off. A soil survey showed 65.7 per cent. of the depleted area A badly eroded, whereas on the well-vegetated plot B only 11.5 per cent. of the area had been so denuded of its surface soil.

Area B has had throughout a plant cover occupying 40 per cent. of the surface of the ground and the other from

LARGE AREAS OF HIGHLY PRODUCTIVE ORCHARD AND FARMS LANDS IN UTAH WERE COVERED WITH DEBRIS TO A DEPTH OF SEVERAL FEET BY FLOODS DURING 1930.

1912 to 1919 had a cover of 16 per cent. Between 1919 and 1924 area A was so treated that its plant cover was built up to 40 per cent. at which level it was kept until the present. There are available for comparison data for two periods, one of 6 years from 1915 to 1920, inclusive, when area A with a 16 per cent. plant cover is compared with B which has an old plant cover of 40 per cent.; and a second 6-year period from 1924 to 1929, inclusive, during which period area A with a newly acquired 40 per cent. cover is compared with area B with the old 40 per cent. cover. In addition, the run-off and erosion from melted snow is compared with the run-off and erosion from summer rainfall in seven of the years.

Sampson and Weyl[1] compared the productivity of non-eroded with that of eroded soils on the two areas. Wheat, peas and native brome-grass were grown in the two soils. They found it required from 2 to 8 times as much moisture to produce an equal amount of vegetable matter, dry weight, on the eroded soils as on the non-eroded. A bulk analysis of the eroded soil showed only 45 per cent. as much organic matter, 35 per cent. as much nitrogen and 67 per cent. as much phosphorous as on the non-eroded soils.

There were each year two fairly distinct periods of surface run-off, one of rainfall from July to September, inclusive, and the other of melted snow from late April to June, inclusive. During the first 6-year period, while area A had a 16 per cent. cover of vegetation, the summer rainfall run-off averaged approximately 913 cubic feet of water and 134 cubic feet of sediment to the acre annually on the depleted area as compared with 153 cubic feet of water and 25 cubic feet of sediment to the acre annually on the well vegetated area.

Only 4.6 per cent. of the total annual run-off from the plot with a 16 per cent. cover was from summer rains as compared to 95.4 per cent. from melted snow. The 4.6 per cent. which was summer rainfall run-off, however, carried an average of 80.1 per cent. or about five

[1] A. W. Sampson and Leon H. Weyl, "Range Preservation and Its Relation to Erosion Control on Western Grazing Lands," U. S. Dept. Agri. *Bull.* 675 (1918).

times as much of the sediment eroded annually as did the 95.4 per cent. melted snow run-off. With the same rainfall, the depleted plot during the summer rainfall period, produced 5.96 times as much run-off per acre and 5.42 times as much sediment as did the well vegetated area.

Between 1920 and 1924 the depleted plot improved to a 40 per cent. cover of vegetation and during the five-year period, 1925–1929, the formerly depleted plot had a cover equal in density to the other plot. It was, however, a newly established cover and had still a soil with most of the qualities it formerly possessed as an eroded plot. The surface run-off from summer rainfall from the older vegetated area was 137 cubic feet of water per acre, almost identical with the run-off for the period 1915–1920, but the sediment was only one third as great. The newly vegetated area showed the effect of the increase in cover by a reduction in summer rainfall run-off from 913 to 297 cubic feet per acre. This, when properly equated against the difference in rainfall during the two periods, is a decrease on the newly revegetated area of 63.8 per cent. in surface run-off due to increasing the vegetation from 16 to 40 per cent. of a complete plant cover. The run-off was still 2.16 times and the sediment 2.48 times as great from the newly vegetated plot. Part of this difference is due to greater slope, part due to better developed gullies, and part due to the lack of organic matter in the surface soil. Unfortunately it is not possible to give these three factors their exact weighting, as each influences run-off and erosion. The increase in cover did not influence the quantity of run-off in the spring from melted snow.

The sediment carried off each acre by summer rainfall run-off of the newly vegetated area averaged approximately 19 cubic feet annually, which is only one seventh as much as the 134 cubic feet which occurred in 1915–1920. When properly equated against the reduction in erosion from the older vegetated plot, there was a decrease of 54.2 per cent. due to increasing the vegetation from a 16 to a 40 per cent. cover. The erosion due to melted snow run-off was reduced 57 per cent. as a result of increasing the plant cover.

Erosion on Granitic Soil

Preparatory to a thorough-going erosion experiment now being started on the Boise River watershed in central Idaho, an examination of the soils has been made in 40 to 50 places which indicate that erosion has been very active in places on the loose granitic soils of this watershed. The herbaceous plant cover has been materially reduced in recent years, probably on account of a series of dry years, heavy rodent infestation and overgrazing by live stock.

In about a dozen places the soil examined was intact and well-preserved. On the upper part of the Fall Creek drainage, a tributary of Boise River, there was found a site of 10 to 15 acres of deep fine soil. The surface 6 inches is fine, black and rich in organic matter. At a depth of from 6 to 18 inches is a layer of fine gray-brown soil apparently rich in available plant nutrients and relatively high in organic matter. From 18 to 30 inches is a coarse gritty, sandy loam, beneath which is 10 inches of coarse sand on top of disintegrated granite. There are thousands of acres that were somewhat similar on parts of Fall Creek, Smith Creek, Slater Creek, Trinity Creek, Roaring River, and other tributaries. Except for small islands of good soil mostly less than an acre and frequently only a few square rods in area, the layer now exposed on the surface in these locations is the infertile, gritty layer that occupied the 18- to 30-inch depth profile on the good site on

THE SAME AREA AS SHOWN IN ADJACENT PHOTOGRAPH IN 1925, AFTER 15 YEARS OF REGULATED GRAZING. VEGETATION IS SLOWLY HEALING THE SCARS OF DENUDATION.

Fall Creek. Of course the two top layers of good soil originally were not everywhere as thick as on Fall Creek. They probably varied from an inch or two to the 18-inch section studied. There seems only one justifiable conclusion, namely, there has been a wholesale loss of the more fertile top soil. Allowing for extraordinarily steep slopes, rocky areas and ridgetops, which probably never were well covered, at least half of the open grazed area is heavily injured due to loss of the highly productive top soil, exposing the loose gritty subsoil which is not particularly fertile. No observations were made in the timbered or brush-covered areas.

A survey of a body of approximately 129,000 acres on the watershed in 1929 indicates that serious erosion to the extent of deep gullying is occurring on 2 per cent. of the area, fairly serious erosion on 15 per cent. of the area, and sheet and light gully erosion on 56 per cent. There is no noticeable erosion on the remaining 27 per cent. which is mainly covered with dense timber or brush.

A further indication of abnormal erosion on this watershed is the accumulation of excessive gravel and sand deposits at the mouths of some of the smaller tributaries of the Arrowrock Reservoir and a layer of one inch to a foot in depth of fine black silt high in organic material over most of the bottom of the storage basin. Between 1912 and 1927 from 7,000 to 8,000 acre-feet of material was deposited in the reservoir which originally had a storage capacity of 276,000 acre-feet.

General Observations

In addition to the cases studied specifically, there are many canyons and mountain valleys that show unmistakable evidences of a recently greatly accelerated rate of erosion. In Utah there are probably hundreds of such cases, three of which will be reviewed

briefly. These are Kanab Creek and Long Valley in the southern end of the state, and Price River, all draining areas covered with a fine sandy soil derived largely from sandstone.

Kanab Creek is a small stream which formerly flowed harmlessly down its canyon and out over a strip of good farming land, emptying directly into the Colorado River a few miles below Bright Angel. It meandered back and forth between banks lined with willows and grass. Nowhere was there any gully to speak of. As late as 1895, a man could, except during the periods of freshet, hop from one bank to the other. Then overgrazing and untimely grazing became common on its small watershed and along its banks. The vegetation on the land adjacent to the channel was further broken by cultivation, roads, etc. In a few years a gully was cut to a depth of about 50 to 100 feet, and from 100 to 300 feet in width. Side gullies are now working back into the farming land and into the public domain lands of the section. The canyon bottom throughout most of its lower reaches is swept practically clean of soil, bedrock being exposed almost continuously.

Across the mountains from Kanab Creek and some thirty miles northwest, one of the upper branches of the Rio Virgin flows through Long Valley. In the early days of settlement in Utah this valley was occupied by a series of colonizing groups. The valley, though only from a quarter to a half mile in width throughout much of its length, was highly productive. Under intensive irrigation agriculture, supplemented with range live stock, the people lived in moderate circumstances. Simultaneously with disastrous erosion on Kanab Creek, the stream in Long Valley rose repeatedly to freshet proportions and gullied a channel the entire length of the valley. For at least 20 miles the gully is 10 to 30 feet deep and is widening during every heavy storm by undercutting and caving. Perhaps

THE HEAD OF A SMALL MOUNTAIN STREAM IN CENTRAL UTAH, IN 1910, BADLY DEPLETED OF VEGETATION BY GRAZING AND DEEPLY ERODED.

a fourth of the fertile soil is already gone. Farther down the Virgin, below Little Zion Creek, in the wider valley of the upper Virgin, is Rockville, a farming community of some proportions which has lost more than half its soil to a depth of 10 to 20 feet or more. There is no evidence of an immediate let-up. This condition, thought to be due to uncontrolled grazing on the public domain lands, is wide-spread on the northern and western tributaries of the Colorado River. What this will mean to the storage capacity of the reservoir to be created by the Hoover Dam is easy to conjecture.

A few miles above Price, Utah, on still another branch of the Colorado, some 200 miles to the north, Gordon Creek flows into Price River. In 1900 this canyon had a gently rounded bottom and a stream that meandered. Destructive freshets were either unknown or so uncommon as scarcely to be noticed. Many times in the last ten years floods have poured down Gordon Creek, destroying on two occasions the irrigation flume supported on a high trellis across the recently eroded gully now a hundred feet deep and 400 feet wide. Nearby, at Castlegate, the main line of the Denver and Rio Grande Western railroad twice in the last decade has been covered with boulders weighing 10 to 50 tons. Automobile highways leading east from Castlegate up Willow Creek and northwest up Price River Canyon have lost their bridges and great sections of the road grades at least every second year during the last decade. Price River, in 1927, had high water or floods twenty-five times and bridges were washed out three times, between June and September. The railroad was either impassable or capable only of emergency use for weeks. Within a radius of 30 miles from Price there are at least 50 major gullies.

Place of Vegetation in Preventing Soil Erosion

Research data presented from the permanent run-off and erosion study areas at the Great Basin Branch Experiment Station, from the detailed field studies on the Davis County, Utah, watershed, and from granitic soils in Idaho show that perennial vegetation plays a leading rôle in the prevention and control of soil erosion, and even has a great deal to do with reducing or preventing the destruction by floods in the Intermountain Region. Given an opportunity on depleted and eroded range areas, vegetation will begin to heal the gullies and lessen the injury caused by erosion. It is not perhaps possible in the present status of our research information to list all the ways in which vegetation may control erosion and prevent serious floods. However, several of the contributions made by plant cover toward soil stability have been clearly manifested.

(1) As Lowdermilk[2] has demonstrated, the organic litter itself in or on the surface of well vegetated soils absorbs water, but primarily keeps the underlying soil opened to rapid and deep percolation, whereas with bare soil the interstices are soon sealed up by the fine soil particles carried in the run-off, thus decreasing the rate of absorption and increasing surface run-off.

(2) Observations on the Davis County watershed in Utah, on the granitic soils in Idaho and elsewhere make it clear that the accumulation of run-off from torrential rainstorms into streamlets and the formation of gullies on slopes is very much in inverse proportion to the density of plant cover. On heavily vegetated slopes with a natural accumulation of plant litter there

[2] W. C. Lowdermilk, "The Influence of Forest Litter on Run-off, Percolation and Erosion." *Jour. Forestry*, pp. 474–491, April, 1930.

was not sufficient surface run-off from the semi-torrential storms of 1930 to leave a trace of gully erosion. Where there was moderate vegetation the water accumulated in streamlets and began to cut for short distances, but the vegetation, both the living plants in place and the accumulated dead material on the surface scattered the streams, caught the soil that had been picked up, and prevented the accumulation of the streamlets into currents of gully-washing proportions. In other words, moderate vegetation kept the water always in driblets and prevented torrents. Where the vegetation had been heavily depleted, the streamlets accumulated into larger currents and these into torrents that traversed the slopes from top to bottom and gouged gullies that varied from small "shoestrings" near the top, to washes 10 to 20 feet or more in depth at the bottom of the slope.

(3) The roots, and to some extent the tops of perennial plants, actually bind the soil and hold it in place against erosion.

(4) Once begun, floods and erosion form a sort of vicious circle. In the beginning surface run-off makes gullies, but after that the gullies permit such a rapid accumulation of surface run-off as to become an important agency in the occurrence of floods from heavy rainfall of short duration.

Moreover, the sediment carried by water becomes a tool of abrasion. The rocks in the bottom of the river just above Niagara Falls are covered with moss and algae. The same is true of mountain streams from well-vegetated watersheds. Let the stream become turbid for a few hours and the sand driven by the current rasps the rocks clean. Sand and gravel borne by a current cut rapidly whereas clear water has little effect.

The volume of a flood is considerably increased by the earth carried by the water. If 5, or 10, or 20 per cent. of flood as it comes off a slope is silt, sand, gravel, stones, and other débris, the volume is just that much greater.

(5) Falling water on well-vegetated slopes is retarded in its downward movement. Delay of a few minutes permits percolation to become of consequence. Delay also distributes the run-off over a greater period of time, thereby avoiding the formation of great heads of water which gain enough velocity and, with sediment, enough cutting power to rip out gullies and roll great boulders. A stream from a well-covered watershed may have either no high water or may distribute it over several to 24 hours, whereas a similar storm on the same watershed after it is denuded and gullied may all run off in from a few minutes to an hour.

(6) As shown in the depleted experimental erosion area, an increase in vegetation soon catches soil in the bottoms of the small gullies. The soil loss was decreased in three years to such an extent that the sides and bottoms of the gullies from one to four feet deep were noticeably in the healing stage.

A NUCLEAR CENTURY[1]

By Dr. LESTER W. SHARP

PROFESSOR OF BOTANY, CORNELL UNIVERSITY

In eighteen hundred and thirty-one, just one hundred years ago, Robert Brown, the celebrated British botanist, announced his discovery of the nucleus.

I am the nucleus!
The world of organisms is my spacious stage:
In toads and toadstools, cycads, cabbages and kings
I play my myriad rôles.
Without my will, kings were not regal, tadpoles toads,
Nor Brassica your sustenance.
Before you in a million representatives I lie
Like karyoplasmic star dust in a universe of cells.
In each of you is some per cent. by weight of me;
So, Homo, canst thou "know thyself" unless thou know'st thy nuclei?
But not to boast I come to-night:
'Tis rather to salute you on a hundred years' acquaintance.
Accept, I pray, this brief recital of my own experience
While yearning for discovery and striving for position
In the sun of human understanding.

PROPHASE

Long, long ago, in times remote beyond the span of mind, the earth,
New-made but old, through chilly space its lifeless course pursued,
Led onward by a flaming star whose genial rays
Brought promises to lake and soil and saline sea—
Inorganic desolation's home: so rolled the planet on.
How came my kind upon the scene I can not tell.
Tradition holds that in some ancient sea the sun
By unsuspecting colloids did beget a prodigy—
A primal, autocatalytic slime which hopefully respired.
'Tis said, as eons came and went my elements did aggregate
To function with a new consistency;
And there, behold, was I!
'Tis also guessed that I lived first and somehow round about me
Synthesized my cytoplasmic dwelling place.
The truth, I fear, is lost; can you, O Homo, self-styled sapiens,
Discover where it lies?
Too long for but a single night, the story of my endless struggle
Aiding organisms in their long unfolding—
The ordering of my parts; the mergers, losses, rearrangements;
Resistance and submission to the force without;
The trials and errors numberless which went upon the rocks
Where you who run may read them.
Through all my fortune's fluctuations did I keep the faith

[1] Presented as the address of the retiring president of the Botanical Society of America at its annual banquet in New Orleans, December 30, 1931.

Until from time's slow toiling mill there came,
Far up from slimehood's low estate, that crowning trio:
Fruit fly, maize and man.
In Asia, old Neanderthal and Crô-Magnon
You made your epic rise, not knowing of my aid.
With blades of fair Toledo and Damascus
Sectioned you yourself and me, yet saw me not.
Such rude technique could never serve for my disclosure;
Savagery was ever deaf to messages like mine.
I felt a warming ray of hope when men of peace
Began to fashion glass to aid their feeble eyes
And peer about them curiously.
In Holland, England and the sunny south I fell
Beneath the microscope's cold, glassy stare.
Within pellucid cells displayed I all my nuclear charms,
Entreating your acquaintance.
"It will not now be long," I thought, as o'er me swept
The glances of Van Leeuwenhoek, Malpighi, Grew, et altera,
And later, of Purkinje, Meyen and Brongiart;
But one and all they turned away to treat of lesser things.
So passed the fruitless years away, and ever lower, deep despairing,
Sank within me my nucleolus.
Then came at last the day. 'Twas in an orchid leaf,
Where I, with silent diligence, engaged in forty foliar functions;
'Twas there, with light upwelling from below,
I felt an influence run me through—a keen and penetrating thing
Like some new cosmic ray.
I sought with eagerness its source, and darkly through the glass above
Descried the eye of Robert Brown, "botanicorum princeps."
Steadily it gazed, and with a cast of thought;
It roamed o'er all the tissue searchingly,
Yet always came to rest on me.
The epidermal cells intrigued the searcher most
(In them I did look rather well);
He saw me also in chlorenchyma
And in the hairs which clothed the surface o'er;
And then, convinced that I should speak to all mankind,
He wrote his brief but cytoclassic record.
Ne'er will fade the memory of the thrill which ran
Through every fiber of my tense reticulum;
An age-long hope was coming to fruition!
How my membrane palpitated!
Every tiny microsome rejoiced with me
In dizzy Brownian dance!

METAPHASE

Through the eyes of Robert Brown and those who followed him
There came to me a new and rich experience,
To you the promise of advance undreamed of (save alone by me).
Harken to the words which introduced me to your world of men:

"In most Orchideae each epidermal cell contains
A single round areola, convex and granular, and lying variously.
Now this areola, or nucleus, as we perhaps may say,
Is not confined to epidermal cells,
But shows itself in divers other places, even in the pollen.
Nor is it to Orchideae peculiar:
Lilies, asphodels and other monocots display it, too.
Not often in the dicots is it evident,
Though in maturing microspores it may perhaps exist."
How quaint in retrospect this utterance of other days!
How meek a mighty river at its source!
Had what I've told been all,
No message of commemoration would I offer unto you;
No pseudopoem would you now endure with gracious charity.
Not only did you see afar the borders of a strange, new land,
But you approached it with courageous, if uncertain, step
To make its treasures known.
No sooner had you dubbed me "Nucleus" (imagine, "Little Nut"!)
Than you began to press me, as between the cracker's jaws,
To ascertain the secrets of my inner life
And publish them abroad, as is the wont of men.
"How come the nuclei to be, and how the cells?
I'll tell you how it is," exclaimed the fiery Schleiden;
"All who disagree with me are wrong, and what is more,
Incapable of being right! 'Tis thus:
Within the limpid liquor of the cell
A granule forms by simple condensation;
Other granules cluster round and form a cytoblast;
A vesicle upon the cytoblast takes origin and swells,
Engendering a cell anew within the parent cell."
Though pleased to be assigned a rôle in cell formation's drama,
Vexed was I by Schleiden's strange opinion of my playing:
I, a heap of granules innocent of ancestry!
The cell, a cytoblastic blister!
Such phantasies, though doomed to early death,
Sufficed for Schwann's far-reaching theory,
Which later lived without them.
Their fate was sealed as they were born
By Unger, Nägeli and the great Von Mohl,
By Kölliker, Remak and all the rest
Whose names still live for you and me.
More deeply did these men of patient and attentive mind
Appreciate the import of the spectacle before them.
They saw the reproductive paradox enjoyed by nuclei and cells—
The way we multiply by just dividing,
Each yielding up his self to two, these two their selves to four,
The four to more, and so ad infinitum.
'Twas we who labor for the good of men,
And not some little corporal, who first exclaimed,
"Divide and conquer!"

Fraught with deep significance for you
Were many features of this metaphasic period,
But none held greater promise than the gradual discovery
Of life's colloidal hiding place,
When science took the slime rejected by the old anatomists
And placed it at the head of cell research's corner.
Ever fairer with the passing years
Grew human views of protoplasm, cells and me,
Until Max Schultze's able pen proclaimed
The cell a protoplasmic entity,
Its parts arising by division of their kind.
Slowly had I struggled to this metaphase of my career,
But now I seemed to feel myself all set, as on a mark,
For quickened anaphasic progress.

ANAPHASE

How am I, the nucleus, to sing the praises
Of Zellforschung's classic period—
That final quarter of the nineteenth century,
When first I took my rightful place among you?
Would that mine might be the words of Athens' ablest bard,
Or what is more, of him who writes your automobile ads!
My lonely progress toward discovery had ill prepared me
For the battle for my favor now begun by worthy men.
My rise in popularity, I fear I must confess,
Accompanied the use of artificial aids to beauty:
With carmine and with safranin my countenance was flushed,
While logwood brew (one-half of one per cent.) evoked my subtler charms.
To-night I seem to breathe again that osmicated atmosphere
And hear the measured music of the Minot microtome.
I seem to see a vision of those champions of mine
Who toiled to lay foundations firm for karyology:
Strasburger, Flemming, Bütschli, Hertwig,
Boveri, Fol and Van Beneden.
In those days were there gigas types;
How gigas, too, their legacy to you!
To minds prepared I gave the deeper secrets of my origin
And saw them shake the scientific world.
I taught them how in tissue cells 'tis always by division
That I propagate my kind; no other way I know.
From one spring all the soma's nuclei, a karyotic clan;
Whence now this one, progenitor of all?
In eggs of worms and angiosperms I next revealed to waiting eyes
An esoteric wonder: syngamic nuclear fusion.
This mutual self submergence ('tis an ancient nuclear custom)
Long has been my trusted means of self advancement:
I have divided, yes, but also have I fused to conquer!
I'm like a netted thread which runs throughout the living world
Uniting all through time and space in one vast family.
In all the century no weightier thing you learned

Than "omnis nucleus e nucleo."
Before the classic days of which I speak
Men claimed that I dissolved and formed anew in duplicate
Whene'er a cell divided. The keener sighted
Spied a group of bodies equatorial
But comprehended not the messages they bore.
Then came the famed "Zellbildung und Zellteilung" and the like,
Picturing my passage through the phases of mitosis.
They showed how my reticulum a thready form reveals;
How all the threads are doubled and become assorted rods;
How these go into metaphasic huddle, hesitate,
And then, the spindle guiding, go gliding to their goals,
Where once again they settle down to metabolic labor.
More public every year became the private lives of chromosomes
(A name you doomed my luckless rods to bear).
You founded gossip sheets with long and ponderous names
For stories of their strange behavior, actual and fancied:
Their number in the soma as it grows;
Their pairing and divorce in reproductive cells;
The greeting of their partners new in each succeeding zygote;
Their cautious march in embryogeny—
In chromosomal terms you wrote the cycle of the life
Of almost every sort of living thing
From lowly protist upward (as the saying goes) to man.
Of what significance, this drama so unfolded?
What mattered it to you, this syngamy, spiremic split,
Synaptic urge and chromosomal continuity?
'Twas syngamy that tempted with a clew:
A fusing gamete might be nought but nucleus
And yet endow the offspring with a worthy heritage.
Heredity now claimed in me a vehicle:
Behind my sleek sphericity I hid determiners
Employed in fashioning successive somas
Saved from dull monotony by amphimictic variation;
Thus, in speculation keen, concluded August Weismann.
So equipped with basic facts, new aids to hand and eye
And theories provocative of mental light and heat,
Your karyologists attained the nineteenth century's end.

Telophase

Our joint adventure's latest phase was heralded
As by a star, which, after long eclipse,
Shines forth to guide the traveler aright.
Long years before, at Brünn, the Königskloster's abbott
Had told the tale of Pisum's progeny
And found for you the rule of one-to-two-to-one.
This simple beacon failed to penetrate the mists
Then drifting o'er the landscape of genetics
Till, the century complete, three wise men caught its beams anew.
Straight down its widening path of light they moved

To find deliverance from old obscurities
And add new luster to the name of Mendel.
The world now knows it was to me that you appealed
For explanation of phenomena displayed
By peas and mice and four-o'clocks;
It knows the story of synapsis and disjunction,
Diplosis wrought by blending syngamy
And all the other chromosomal deeds, somatic and meiotic;
It knows the evolutions odd
Through which I send my genoms ever cycling on
To be the new genetics' master key.
Ever wider swung the doors this key unlocked,
Admitting you to understanding new of coupling and repulsion,
Withering sterility, the embryo's resolve to bear
The spear and shield of Mars or Aphrodite's mirror.
Through many turnings of the genic labyrinth
Drosophila melanogaster led the way:
How typical of New World opportunity,
This creature's sudden leap to fame from off the pomace pile!
My ever growing prominence in world affairs
Required new portraits of my chromosomes
Still quaintly shown in public prints with eighteen-ninety lines;
But after men of Serge Nawaschin's skill had scrutinized them well
They showed more modern silhouettes,
With arms, attachment points and satellites,
While up and down within them crooked chromonemas ran.
Early was I called upon to demonstrate my strategy
In hybrid plants, where I, though equal to somatic matters,
Often felt embarrassed by synaptic diffidence:
My chromosomes forsook their old meiotic minuet
And danced alone in solemn univalence,
While I was saddened by the youthful spores I saw zugrunde going.
Long did I perplex you with my frequent polyploidy,
A puzzle cytoarithmetical in which you now perceive
A likely clew to species alteration.
Your vaunted analytic powers I tested with a special trick,
Segmental interchange, wherein my chromosomes
Joined hands in diaphasic chains and zigzagged in the anaphase.
You saw the point (when twenty years had passed!):
With Jimson Weed and Zea Mays you solved the mystery
When all were growing weary of the evening primrose path;
And then, to prove again your power, you wrung from me
The long awaited proof of chromosomal crossing-over.
Meanwhile other groups of men, commendably original,
Assailed my stronghold with another set of weapons:
Microprobes and Lilliputian squirt-guns,
Acids, whirligigs and vital dyes—
All these did I endure to further karyology.
They stretched me out between two pins and twenty-two opinions new
Concerning what I knew not that I had, pH.

I felt the X-ray's quivering urge suffuse me through,
Dismembering my chromosomes with no respect
For preëstablished order, like overzealous dust maids;
But in dismemberment they cast a vote of confidence
In strange hypotheses of linkèd genes
And moved a few amendments.
Behold therein how jolts from old routines
Evaluate familiar points of view!
So now I come to nineteen hundred thirty-one,
A century since my début, still young,
And with a will to point the way to ever greater conquests.
I hold the key position in a powerful alliance:
Cytology, genetics and a new taxonomy.
With you and me thus trebly armed to carry on
As artificial barriers dissolve in time away,
Who now shall stay our march?

INTERPHASE

The past is in the past; it's in the future, too:
Biology can never be as though I ne'er had been,
For what I taught you in the century just gone
Will color all your thoughts of life to-morrow.
To-morrow's thoughts! O whither will they carry you and me?
The doctrine of heredity so bravely built
On Weismann's daring plan must be the more refined
And made to yield a greater human service.
Concerning genes I'll strive to teach you more:
The nature of the things they are—and aren't;
The portion of my work for you they do—and don't;
How in metabolism's course they turn ontogeny;
The measure of their worth in evolution's grander schemes.
Be not content with inference from end results:
My whole life cycle, as I live it, must you know;
With keener methods must you probe my physiology
And search development for light upon heredity's enigmas.
'Tis homely, solid facts you need;
You'll know no dearth of speculative vapor.
With lenses, tissue flasks and subtle radiation,
And now and then a bit of cerebration,
You'll execute refined analyses.
Be sure analysis with integration joins
If you would know the organism whole and my position in it!
Through all this quest consider well the faithful cytosome
Who with me lives to forge our protoplasmic destiny;
The plastids, vacuoles and elements of doubtful pedigree
Are all my partners in the work of life;
'Tis we, not I, who build the race!
What men have learned is but a minor part of what I have to teach:
Could you perceive the Unknown's vast extent
You'd know the meaning of humility.
In every corner of my field is room for many tillers.

I fain would see outgrown with shame that staking out of claims
Which shows so well the end for which the work is done.
Fear not the duplication of your efforts!
Rather should each worthy task be thrice performed;
The truth you seek deserves security!
This many-sided venture, I foresee, will bring to sympathy,
If not to understanding, self-sufficient specialists
With souls corroded by a mutual suspicion.
The science of the living, like to that which lives,
Will prove itself to be a unitary whole,
And not until it banishes intolerance
Can it attain coherence in its own philosophy.
New knowledge brings to you new power, not always common sense.
As busy years which lie ahead speed hither to your service,
Will human right to be well born be met with opportunity
Like that enjoyed by pampered Bos and Equus?
Can anybody tell?
Will power to mould development be used with vision broad,
Or will the standardizer's baleful influence prevail
And bid you ever live with neighbors like yourselves?
And in your schools, will you who would enjoy your work,
As well as you who would employ the worker,
E'er escape the thraldom of the Ph.D.?
Will native worth be freed from ruddy ribbon's snares?
Such hopes are ever in me.
Will genes of wisdom dominate the potent genes of size and speed
Which, uninhibited, oppress your human kind?
Will values then be better judged than now?
I wonder, when a miracle of science
Stirs the ether mightily with sublimated piffle
And the dismal drivel of moronic song.
My courage falters when I see great trees I strove to fashion
Slain to carry fiction's flood of dirty ink.
I tremble for the future when I witness
Art betrayed by studied ugliness
And statesmanship by craven politics.
But optimism is a nuclear trait;
So far with you I otherwise could ne'er have come.
I've seen you rise and fall and rise again since I began;
So let another century of human effort roll its course
While I roll mine, expecting much and hoping for the best.
In that far distant day when hopes of supermanhood are fulfilled
And sapiens becomes a fitter name,
Recall, I pray, your ancient debts to me, the humble nucleus,
To Theodor of Würzburg and to Eduard of Bonn
And all the pioneering band who followed in the steps
Of Robert the Discoverer.

RESTING STAGE

THE APPALACHIAN TRAIL:

A GUIDE TO THE STUDY OF NATURE

By BENTON MACKAYE

ORIGINATOR OF THE APPALACHIAN TRAIL; VICE-PRESIDENT, REGIONAL PLANNING ASSOCIATION OF AMERICA

The best way to become acquainted with any scenery is to engage in some pursuit in it which harmonizes with it.—*Thoreau.*

THAT is why the Appalachian Trail was started—to become "acquainted with" scenery; to absorb the landscape and its influence as revealed in the earth and primeval life. The way to attain this is to do something, not just admire something. To engage in some harmonizing "pursuit"! To build a foot trail several hundred miles long through the scenery of the Appalachians on the crestline from Maine to Georgia: this is the first pursuit which several hundred young persons have accomplished during the past ten years. Such is their first long step in the longer pursuit of becoming harmonized with scenery—and the primeval influence.

Primeval influence is the opposite of machine influence. It is the antidote for over-rapid mechanization. It is getting feet on the ground with eyes toward the sky—not eyes on the ground with feet on a lever. It is feeling what you touch and seeing what you look at. It is the thing whence first we came and toward which we ultimately live. It is the source of all our knowledge—the open book of which all others are but copies.

What pursuit can we engage in, on the Appalachian Trail, "to become acquainted with" the scenery it traverses? That is the subject of this article. It is to learn how to read. How to read the "open book"—first hand, not tenth hand. How to read the story of the earth—a particular part of the earth—the Appalachian earth and the life thereof. The earth story is told in the structure of the Appalachian Range; the earth's life is disclosed in the forest on its slopes.

The forest indeed is a whole civilization: it is a close-knit society of plant and animal life containing every race alive save one. That one is man. He has made another civilization. He calls it "human society." Human society is an offshoot of forest society. Each has its history. To know America we must know human history, and to know humanity we must know forest history.

But the earth story precedes the forest story. One is contained in the Appalachian Range and the other in the Appalachian Forest. We can read them both—first-hand—from the Appalachian Trail.

THE APPALACHIAN TRAIL

The Appalachian Trail is a footpath on the crestline of the Appalachians stretching from Maine to Georgia: its projected length from Mt. Katahdin to Mt. Oglethorpe is estimated at 2,054 miles, of which about 1,400 are completed. Being a foot trail and not a motor road it traverses the highest and wildest portions of the mountains: the White Mountains, Green Mountains and Berkshires of New England; the Hudson Highlands of New York; the Blue Mountain Range of Pennsylvania; the Blue Ridge of Virginia, and finally the Great Smokies of Tennessee and North Carolina. It has been made (and is being made) by local clubs all along the line. It coincides in many places with the main trails of such local clubs which have equipped their sections with shelters and cabins.

The plan was proposed ten years ago as a "project in regional planning" in an article by the author which appeared in October, 1921. In 1925 the Appalachian Trail Conference was formed, consisting of a loose federation of all the local clubs. An executive committee of eighteen persons, headed by Mr. Myron H. Avery, now has the work in charge. The Trail traverses several National and State reservations (both forests and parks) and forms the backbone for projected reservations in between. The Appalachian Trail indeed is conceived as the backbone of a super reservation and primeval recreation ground covering the length (and width) of the Appalachian Range itself, its ultimate purpose being to extend acquaintance with the scenery and serve as a guide to the understanding of nature.

The first decade of the Appalachian Trail project (just completed) was devoted chiefly to getting the idea started and to making the physical trail. The project now enters (in 1932) upon its second decade and upon its second stage of development. How to use the 1,400 miles of finished trail to develop a primeval understanding? The answer suggested is to learn how to read—firsthand. To read the earth story contained in the Appalachian Range and the life story contained in the Appalachian Forest.

The Appalachian Range

The Appalachian Range occurs in two generations—the Older and the Newer. The "Older Appalachians" form a chain from the Great Smokies in the South to the White Mountains in the North. This chain is broken in one place only—in the vicinity of the Susquehanna River (Pennsylvania). Southward, it consists of the ancient crystalline Blue Ridge; northward, of similar ancient stock contained in the Hudson Highlands and the various New England ranges. The "Newer Appalachians" or Allegheny Mountains (a sort of magnified ploughed ground) flank the "Older" on the west side. Between the "Older" and the "Newer" Appalachians lies the corridor known as the "Great Valley"—from Chattanooga to Lake Champlain.

East and west of these twin ranges we have a symmetric pattern of plain and plateau (see Fig. 1). East of the Older generation lies the southern Piedmont and the New England Upland (these ancient crystalline areas being separated in the Susquehanna district by the young sandstones of the "Triassic Lowland"). West of the Newer generation lies the middle-aged Allegheny Plateau. East of the Piedmont comes the Atlantic Coastal Plain, newly emerged from the present (eastern) ocean. West of the Allegheny Plateau comes the Interior Lowland—an older coastal plain emerged from an older (western) ocean.

The Appalachian Trail follows the crest of the Older Appalachians—except at the break near the Susquehanna, where it crosses over to the Newer generation (along the Pennsylvania Blue Mountain Range). In so doing the Trail twice crosses the Great Valley.

A cross-section of the structures occurring in the middle Appalachian region (on a line from Ohio to the Virginia shore) is given in Fig. 2. This shows in sharp contrast the two kinds of rock substance: (1) the "Old Land" or ancient underlying hard crystalline material; and (2) the younger overlying softer uncrystallized material (the layers of sandstones and shales). Of the latter structure, the Atlantic Coastal Plain has been so recently emerged from the sea that it is but slightly affected by the elements; but the Allegheny Plateau, which has been exposed much longer, has become thoroughly "dissected." Hence one is flat, while the other is so-called "mountainous."

A panorama of a portion of the Appalachian Range is shown in Fig. 3—a

FIG. 1

small portion, indeed, but one sufficient to suggest a telling method of reading landscape. This panorama, embracing the horizon from Mt. Greylock, Massachusetts, to Killington Peak, Vermont, is taken from the convenient vantage point of Mt. Monadnock in New Hampshire. A map is subjoined of the territory within this view, but the panorama itself is the natural "map" going with the "open book" of nature. The *panorama* is one of two main leads toward unravelling the story told directly by the great outdoors.

The other lead is the *cross-section*. A sample is shown in Fig. 4. This cuts from crest to base the east slope of the Blue Ridge of Virginia—from the rocky summit of Stony Man to the lowly valley of Nigger Run; also a section taken from the lower stream (the Rapidan River), and another taken at the stream's mouth (on the ocean margin).

Written large on these great natural tablets (panorama and cross-section) are those records of form and substance and process which together constitute the epic of the ages. From the panorama

we see the general features of the landscape; from the cross-section we see what is going on within the landscape.

Let us climb to the summit of Stony Man, and from its panorama make general acquaintance with the primal scenery. Its four elements are there (land, air, water, forest): the hills and dales, the varied clouds, the winding streams, the sylvan coat of summer green (or winter brown).

Let us now descend to White Oak Canyon, and from its cross-section make acquaintance with what is going on within the panorama. To do this we follow the canyon's stream—from its source below the crestline to its mouth beneath the ocean. Thereby we trace, from birth to death, the life course of a being which is neither plant nor animal: it is the "being" which we call a river; a mixture of individual and race—its form as rigid as the one, its flow as eternal as the other. We follow this immortal sculptor of the landscape and trace its work through definite stages, and in definite zones of action: (Fig. 4.)

(1) The zone of Weathering—up on the Ridge's rocky brow. Here in the crevices the stream is born, for here collect the rain waters. They freeze and thaw and crack and heave the solid surface.

(2) The zone of Breakage (or "torrential" zone). Down this we pitch headlong through the heart of White Oak Canyon. Come here in the summer drought and look at the cascades falling gently over the high jutting ledges that peer at you from above the hemlock tops: what effect, you ask, can such drippings have upon the landscape? But come again with the early spring freshets and witness yonder cataracts pouring uproariously over those same ledges. This tells another story: the stream in the might of youth chiselling out the mountain; big jagged fragments becoming small rounded boulders; the water dashing them together and hurling them into the gully below.

(3) The zone of Grinding. In the less steep lower Canyon where rocks "flow" as well as water. A second brook here joins our first one, making the double stream called "Nigger Run." The small rounded boulders are ground to tiny polished pebbles. These rattle and "flow" on together along with the yet foaming waters, turning gradually to sand, the "flow" whereof begins to clog in the less hurried waters.

(4) The zone of Removal and Deposit. We have jumped a gap and taken up our journey far down the river, halfway to the sea. The stream consists now of several "Nigger Runs" which have come together out of the great wall of the Blue Ridge. Its name is Rapidan River. We have shifted from trail to canoe, and this floats with the current around the big bends and meanders of this cosmic "be-

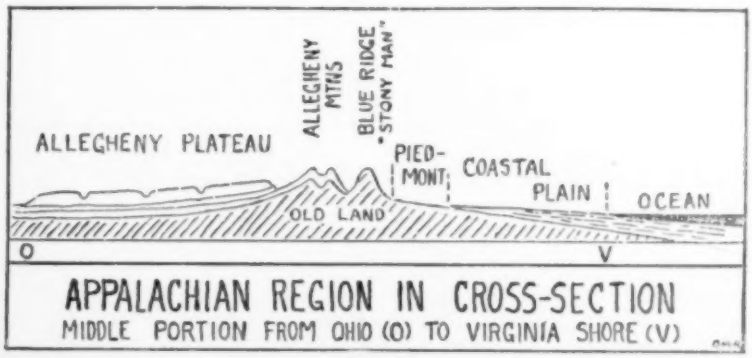


FIG. 2

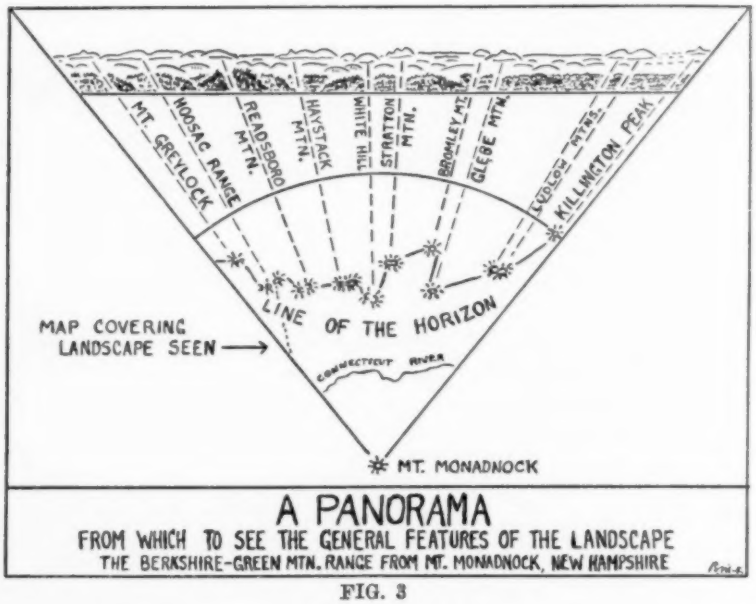


FIG. 3

ing." But there are two currents—one swift and one slow! The swift one follows the outer edge: it gouges into the bank, tears loose the soil and bears it on in that red soupy flow of mud and water —"half and half." Then on the next swing it becomes the inner current and mopes along the inside edge. Unable thus to carry its burden it drops part of it upon the bottom and so builds up the inside bank. The river (as it were) removes with one hand and deposits with the other; but it removes, in the long run, more than it deposits.

(5) The zone of Ultimate Deposit—where the stream form "dies." We jump another gap and end our journey on the margin of the sea. The stream, too, ends its journey; its waters mingle with the great eternal of the ocean, but its soils drop lifeless on the ocean floor to build their little quota of that long "shelf" that reaches around the continent.

Thus we see the river acts as sculptor of the landscape—a cutter and a builder too, but more a cutter than a builder. "Statistics" show that the Potomac River system (not the Rapidan) cuts (or scrapes) each year from the area drained about 1,358,000 tons of solid earth suspended, plus 1,787,000 tons of material dissolved. This material amounts to a layer one inch thick removed from the drainage area every 870 years. This process of scraping is called *erosion*. Thereby is the land removed from places above to places below the surface of the ocean.

In tracing thus upon our cross-section the primal mode of landscape sculpture we get acquainted with the main things going on within the landscape's panorama (except within the forest). We carve an opening into those imposing facts which (as stated) constitute the epic of the ages—the form and substance of the country seen, and the process whereby it is molded. Each map and sketch and photograph, when made with care and due selection, adds to our total picture of the form; every specimen of rock and soil, with accurate note of its location, reveals a bit of knowledge of the substance; any systematic record of

rainfall and stream flow, any map or description of river turn or waterfall, builds up our visualization of the process. In uniting thus the acts of artist, collector and observer we epitomize the Appalachian landscape and in our minds create the setting for the complete primeval story.

Here then is one "pursuit" in which we can engage in order to become "acquainted with" the scenery. It is something which we can carry as far as we like—on the Blue Ridge of Virginia or the Green Mountains of the North, or the Great Smokies of the South, or anywhere else on the Appalachian Trail.

But other pursuits await us if we would truly read the complete primeval story of the Appalachian scenery and range. It is not enough to know this range merely as it exists to-day. Whence came it—and how? What of its genesis?

Genesis of the Range

Let us take a second trip to Stony Man and look again upon its panorama. The surrounding ridges and lowlands mean more to us since our trip down the cross-section and our personal discovery of the great process of erosion. The whole country, as stated, is being slowly cut down and shovelled out to sea by thousands of hydraulic dredges—the rivers. Given time the whole country—if nothing else happened—would be cut down to the level of the sea (so-called "base level"). The soft lands are cut faster than the hard: hence we have the low broad plains of soft and extensive limestones and the high narrow ridges of hard and limited crystallines. Both are cut down slowly but the ridges more slowly than the plains.

Cut down from where?

Something keeps shoving the continents up high above the sea. Else long ago erosion would have ground them down to base level; our planet's surface then would be an endless sheet of ocean and its life limited to fish and lower beings. So something else *has* happened—and keeps on happening. This something else is another process—the counter process to erosion. It occurs in various forms:—volcanic upheavals, lava flows, general uprisings of the land (accompanied by earthquakes). Its name is *uplift*. Its cause is "subterranean"—the working and squirming of the superheated substance beneath the cool exposed earth "crust" on which we live.

This crust originally consisted of cooled-off molten substance—of "igne-

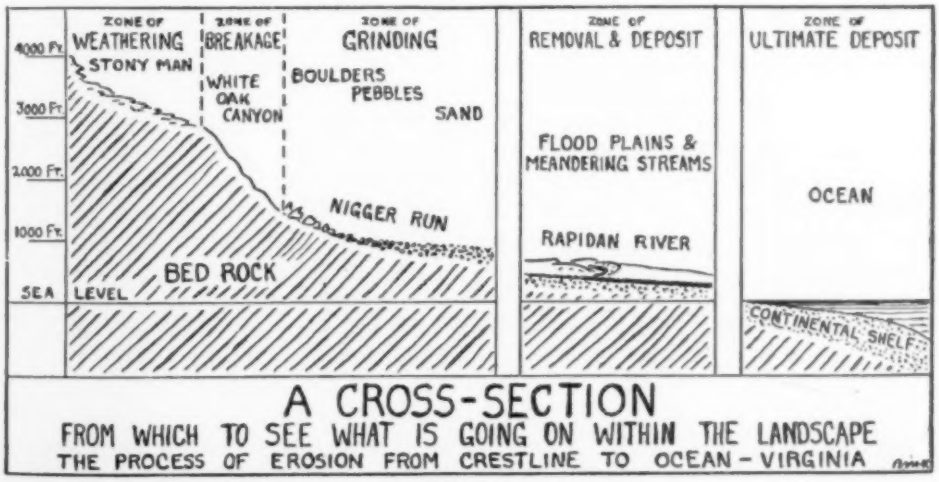


FIG. 4

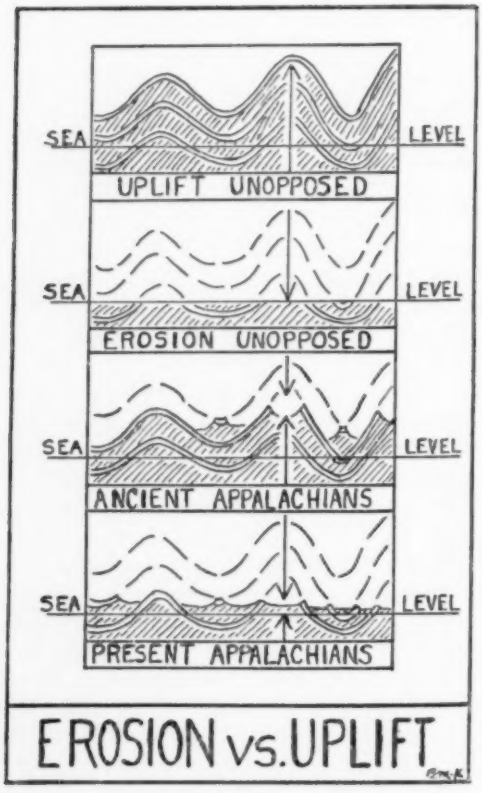


FIG. 5

ous" rocks, the class to which granite and lava belong. These igneous rocks formed the original stuff, stock and ancestry of all the continents. As soon as they stuck their heads above the ocean, erosion attacked them, broke them into fragments, ground them into powdered form, and spread them as freshly made material out upon the ocean floor (as we have seen). This material, hardening into layers (or "strata"), became sandstones and other kinds of so-called "stratified" or "sedimentary" rocks. Hence this new kind of rock was deliberately made and manufactured out of the old, original, igneous rock. We might call them by two names —the primal or fire-made rock, and the "manufactured" or water-made rock.

These layers of stratified or manufactured rock (and re-manufactured rock) have come to form a substantial portion of the earth's crust. As the earth contracts (with its cooling and shrinking) the crust wrinkles up in places (just like the skin on a drying apple).

The Appalachian region is one of those places. Here (late in the Paleozoic Era) several great layers of manufactured rock (some old, hard and crystallized, some younger, softer and even-textured) were lifted and wrinkled into enormous folds. By this process of uplift the topmost layer—if nothing else had happened—would have folded into one or more arches which would have reached possibly 30,000 feet above the sea. But something else of course *did* happen, namely erosion, and the tops of the arches were kept down to less than half of the height which uplift unmolested would have achieved. The Appalachian Range of Paleozoic time might have been Himalayan in stature; but erosion kept it down to Alpine altitudes, and since then has reduced it to the modest Virginian heights such as the top of Stony Man, 4,010 feet above the sea. This balance of forces (erosion *vs.* uplift) is illustrated in Fig. 5, for the several conditions which have been described.

So the tops of the folds were cut off by erosion and placed back on the sea floor whence they came. Here their substance was remanufactured into a second edition of sedimentary sheets and in the course of ages was raised again above the sea by uplift—not in folds this time but as a level or gently sloping plain along the middle Atlantic coast (the "Coastal Plain"). See Figs. 1 and 2. In time comparatively short erosion *via* its meandering rivers (like the Rapidan) will scrape this coastal plain away and place the substance once more on the sea floor—there to harden to a "third edition."

Thus moves the land up and down across sea-level—uplift pushing it up in solid masses, erosion washing it down in

severed particles; thus land itself moves in a series of cycles from sea back to the sea—even as the waters (in their infinitely shorter cycles). And so as the great Huxley says:

> The land is therefore subject to a kind of circulation similar to that . . . in the case of water. The water, it will be remembered, passed from the river to the ocean, and back again from the ocean to the river in the form of rain. In like manner, the solid land is constantly being carried, piece by piece, into the sea. Here most of it is spread out upon the ocean floor, forming deposits which will some day be raised as dry land; and will then be once more attacked by the water, as soon as it rises above sea level. The solid earth is, therefore, subject to a cycle of changes not less complete than that exhibited by the circulation of the waters.[1]

Such, in brief, is the colossal earth story which has been "read" by Huxley and other great readers from all portions of our planet during the past revealing century. From panorama and cross-section, and their fascinating first-hand pages, we "illiterates," too, can learn to read this story. The lead in this would be to find what stage in the land-circulating cycle we now occupy: specifically—what our landscape has looked like from time to time since the cycle began. What manner of "motion picture" may we vision of these shifting cosmic scenes?

Here is another "pursuit" which can be carried on from the Blue Ridge, or Green Mountains, or the Great Smokies, or from anywhere along the Trail:—the reading of the genesis of the Appalachian range.

And next—what about the Appalachian forest?

The Appalachian Forest

We make a third trip to Stony Man—this time to take special notice of that forest at which we took a fleeting glance in our first ascent. Let us first take an outside look at this forest—from the panorama. Then we shall take an inside look—from the cross-section.

In order first to get an *outside* knowledge of the Appalachian forest, and of the distribution of its various types, we must map the panorama not only from Stony Man but from various other points along the Appalachian crestline. As a background for this we shall now in imagination (and with the aid of Fig. 6) map this mountain forest, not only in several places but in several periods. We shall follow through a forest "cycle" (for the forest has its cycles as well as the waters and the land). This one is climatic: it is a little cosmic turnover which has "just recently" occurred, from temperate forest to temperate forest, before and after the last invasion of the ice sheet. This invasion was at its height about 40,000 years ago. This is "recent"—absurdly recent—as seen upon the cosmic time table. Translating to the American history time table and placing the latterly Paleozoic Era at the "War of 1812" would place the middle of the glacial period about six "days" ago.

Our climatic cycle of the Appalachian forest goes back about ten and one half of these "days," or about 70,000 actual years. Since then the Appalachian range itself (save for the scars and mouldings of the ice sheet) has been changed but insignificantly (either by erosion or uplift). At that time our well known temperate hardwood forest (of oaks, maples, birches, and the others) covered the range from south to north (interrupted then as now by lowland evergreens like pine and hemlock).

Fig. 6 shows three climatic forest forms. These exist to-day in three types of North American vegetation: (1) the temperate hardwood forest of the Southern and Central United States; (2) the subarctic spruce forest which crosses Canada south of Hudson Bay; (3) the

[1] "Physiography," by T. H. Huxley, Chapter XIII, pp. 215–216.

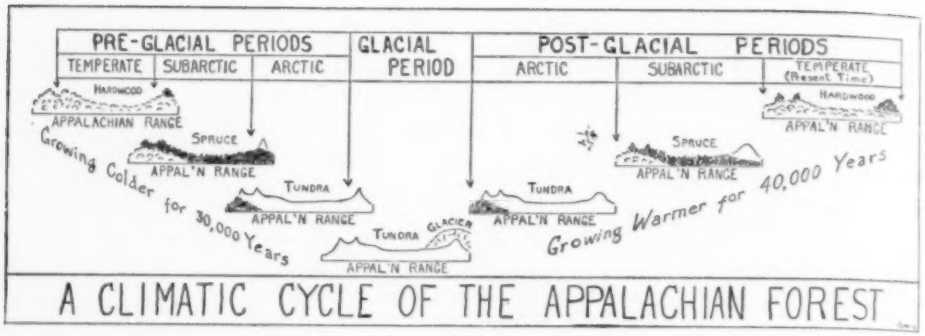


FIG. 6

arctic tundra (of willows, moss and lichen) which occupies the continent northward from James Bay. These three types of forest occupied successively the body of the Appalachian range during the three pre-glacial periods while the ice sheet was approaching from the north; in each period the lower slopes of the southern mountains were covered by the type belonging to the period next warmer, while the upper slopes of the northern mountains were clothed by the type belonging to the period next colder. The glacier at its culmination got about as far south as the Hudson Highlands and the Delaware Water Gap. During the three post-glacial periods, while the ice sheet was retreating, the range was occupied by the three types of forest in reverse order—arctic, subarctic, and temperate.

To-day the temperate hardwood forest is back again, but King Spruce reigns in large portions of the north (when unmolested by mankind). And his realms are also in the south (even as far as the Great Smokies). They occur along the crests and summits in a series of "boreal islands," while the boreal "King" himself, defiant of the encroaching hardwoods, stands forth the rude rugged remnant of subarctic times and reminds us that the cycle is not yet quite complete.

The cycle described is an example of what botanists and ecologists call a "climatic forest succession." There are several other kinds of forest succession—such as the biotic, the physiographic and the anthropic. Any of these might well be explored—on panorama and cross-section—as an aid to becoming acquainted with the Appalachian scenery.

In order now to get an *inside* knowledge of the Appalachian forest—of its species and their mutual relations—we shall again follow the trail down the Ridge's side. As in reading the range, so in reading the forest, cross-section follows panorama. We may retrace our steps through White Oak Canyon to the Rapidan, in quest, this time, not of what is going on within the land, but of what is going on within the forest. What is the make-up of the forest "population"? How does it cooperate to make a living?

"Who's Who" in the Appalachian forest shows the tree family to be the aristocracy. There is white oak himself with the numerous brothers of his genus; there is the sublime tulip; and the ashes, the hickories, the late and mourned chestnut; also the pine and his brother conifers—and about a hundred others. There are the shad-bush and the dogwood and the hundred shrubs. There are the trailing arbutus in secluded dells and a hundred other wild flowers. There are the gorgeous ferns, the mosses on the rocks below, the lichens on the cliffs above, and a world of

fungi in the fallen tree. Down in the pools are green algae that we dispose of as mere "slime."

And then there is the whole animal kingdom—the other half of the forest population. The clam perhaps is one of the lowliest animal citizens. Of insects the castes are legion. There are trout in the brook (let us hope). There are frogs and salamanders, turtles and moccasins. Ducks light on the waters, songsters fill the trees, and the hawk soars up above. Muskrats follow the streams, while squirrels, foxes, wild cats and deer roam the woods generally. King Primate only is absent (except in clothing).

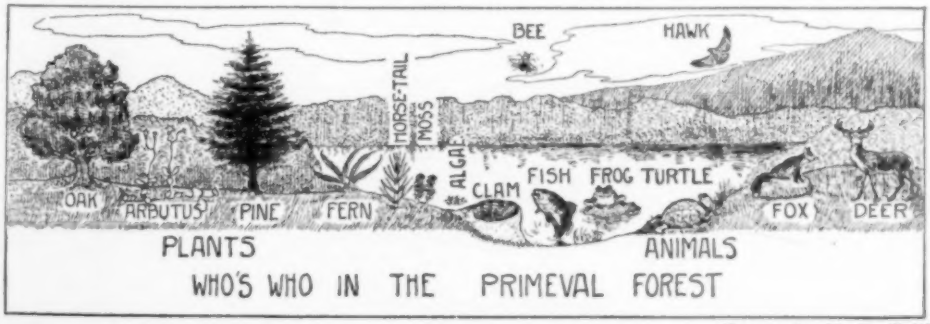
Such is "Who's Who" in the primeval forest. A select list from among them is shown in Fig. 7: plants on the left and animals on the right; the lower orders in the center and the higher orders on each side.

How do they all make a living? Just as men do—by cooperation and division of labor. But (as with men) cooperation bred on the tough experience of competition. The primeval forest is a balanced and independent society. It is still a warring society. It is not an Utopia, it is merely a civilization. Most of its folks live in cities—the ants and bees and hornets. Some live on farms—the lichens that first extract the food from Mother Earth. Others—like foxes—dwell part-time in subways; frogs occupy the waterfront; while songsters make their living in the skyscrapers. Each one is consumer and producer; some "produce" by preying on others; everybody has a job; the less work the less food; resources in plenty and no markets; no middlemen, no salesmen. In unravelling the forest civilization we reveal the contrasts of our own.

Here is one more pursuit for getting acquainted with Appalachian scenery and absorbing its primeval influence—to picture accurately the forest both from outside and from in. From the crestline panorama to trace its outer aspects in the cosmic cycle before and since the glacial period; from cross-section to trace its inner constituents and workings.

The primeval forest is an epitome of all land life except the human. It is worthy of a tracing both comprehensive and comprehensible. In this the collector of specimens (plant and animal) might well play the constructive part, remembering that the value of the specimen lies not at all in quantity but wholly in selection. The collector alone could, with right imagination, reveal to the average amateur naturalist a conception of total life such as he never had before.

But the forest as it is in the cosmic "present" (within the "days" since glacial times) is a small part only of the whole. It forms the end of a story but no evident portion of the middle or beginning. To the pursuit therefore of picturing the forest as at "present" let us add that of visioning its genesis.



Drawn by M. V. Keith

FIG. 7

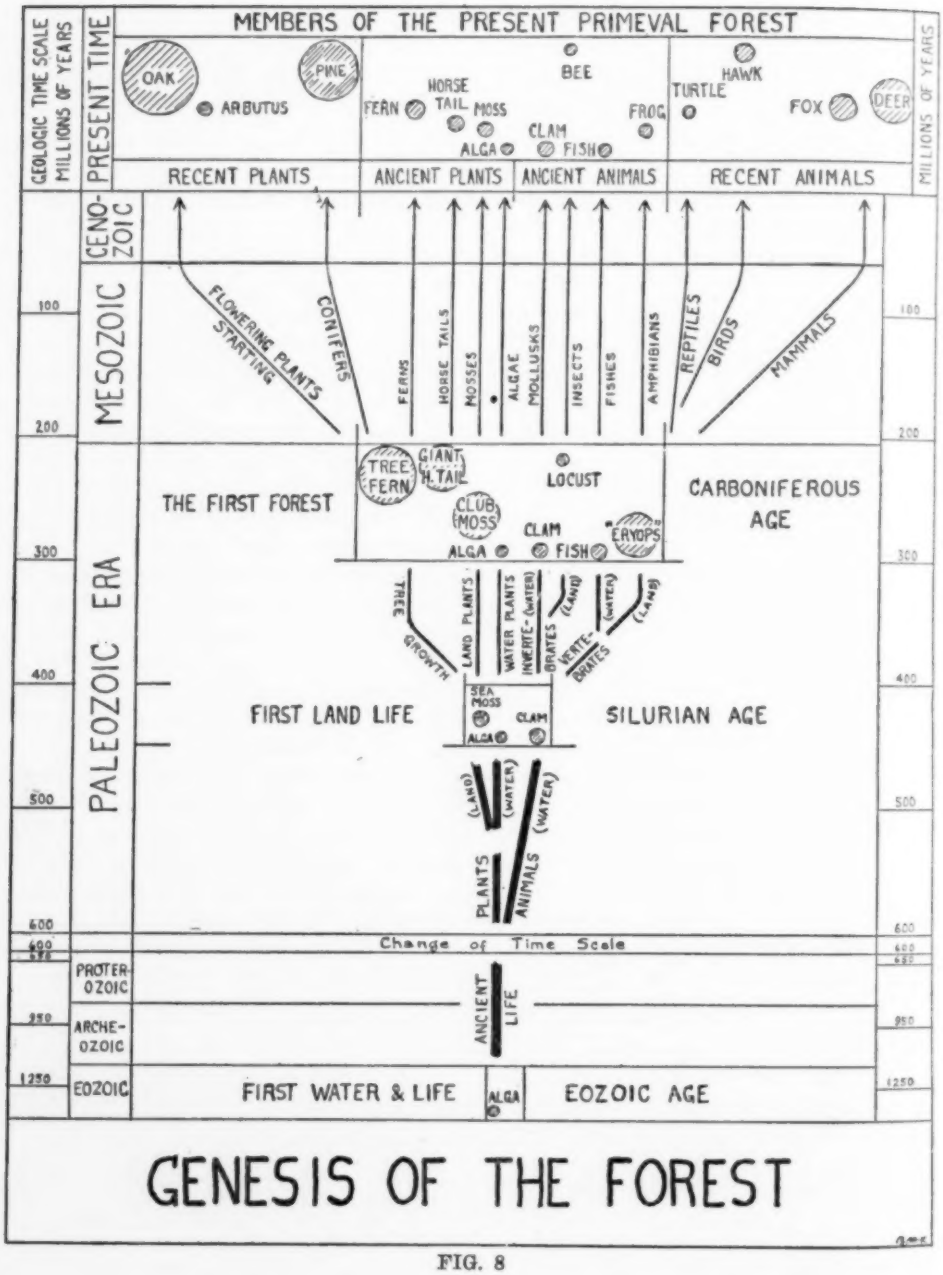

GEOLOGIC TIME SCALE
MILLIONS OF YEARS
PRESENT TIME
MEMBERS OF THE PRESENT PRIMEVAL FOREST
OAK
PINE
ARBUTUS
HORSE TAIL
FERN
MOSS
ALGA
BEE
CLAM
FISH
FROG
HAWK
TURTLE
FOX
DEER
RECENT PLANTS
ANCIENT PLANTS
ANCIENT ANIMALS
RECENT ANIMALS
MILLIONS OF YEARS
CENOZOIC
MESOZOIC
PALEOZOIC ERA
100
200
300
400
500
600
FLOWERING PLANTS STARTING
CONIFERS
FERNS
HORSE TAILS
MOSSES
ALGAE
MOLLUSKS
INSECTS
FISHES
AMPHIBIANS
REPTILES
BIRDS
MAMMALS
THE FIRST FOREST
TREE FERN
GIANT H. TAIL
CLUB MOSS
ALGA
CLAM
FISH
LOCUST
ERYOPS
CARBONIFEROUS AGE
TREE GROWTH
LAND PLANTS
WATER PLANTS
INVERTEBRATES (LAND)
INVERTEBRATES (WATER)
VERTEBRATES (WATER)
VERTEBRATES (LAND)
FIRST LAND LIFE
SEA MOSS
ALGA
CLAM
SILURIAN AGE
PLANTS (LAND)
PLANTS (WATER)
ANIMALS (WATER)
Change of Time Scale
PROTEROZOIC
ARCHEOZOIC
EOZOIC
ANCIENT LIFE
FIRST WATER & LIFE
ALGA
EOZOIC AGE
GENESIS OF THE FOREST

FIG. 8

Genesis of the Forest

We might make a fourth trip to Stony Man, but it would aid us little in visioning the genesis of the Appalachian forest. In this the intimate look-ins on the cross-section are more useful than the sweeping look-offs on the panorama. But first we shall stay at home and survey in imagination the results of a hundred years of intensive research, made since Darwin's day, based on the vague gropings of the centuries since Aristotle. A notion of this survey is shown in Fig. 8.

We have had a look at the "present day" primeval forest—its organization and its various plant and animal members. We might get our collectors to place these members in a row—plant to the left, animals to the right (a sample species for each of the major groups) thus:

Plants (from high to low)—oak, pine, fern, moss, alga (or "slime").

Animals—deer, hawk, turtle, frog, fish, locust, clam.

These members, already shown in Fig. 7, are indicated also at the top of Fig. 8.

A "Who's Who" for the carboniferous forest may now be made by naming the families or groups from which the above species have directly descended:

The carboniferous plants (from high to low): The tree fern, ancestor of the recent low-growing variety; the horsetail and the clubmoss, ancestors of the recent diminutive horsetails and club mosses. These grew as tall as our recent trees. Finally the algae, or green slime on the waters: this type has changed almost none during all geologic time—the same "yesterday, to-day, and forever."

One plant member of the carboniferous forest was of higher order even than the tree fern. This was the giant cycad. But it was a "great uncle" rather than the grandfather of the present Appalachian trees, the conifers being the nearest of kin.

The carboniferous animals: Amphibian, represented by a crocodile-like creature called "Eryops," an ancestor of present animals living in and out of the water—such as frog and salamander. Fish—of various kinds not unlike our moderns. Insect—of numerous kinds, among which are the first cockroaches and locusts. Mollusk, of which the clam is typical.

These carboniferous members (plant and animal) are also shown in Fig. 8.

The luxuriant carboniferous forest which contained these families and grew our anthracite has long gone into fame. We need not describe it in this article. But how can we picture it outdoors? We can not do it from Stony Man, nor in White Oak Canyon. We might do it best perhaps in the Great Dismal Swamp in coastal Virginia; but let us take some swampy bottom at the foot of one of the southern Appalachian ridges. Visualize here a moving picture and run it backward to see what would happen if we could travel back in time: The oak would disappear; the pine would come to look something like its "Uncle Cycad"; the ferns would grow bigger and bigger until they were as tall as our pines—and much more sprawling; the deer, the fox, the birds, the reptiles all would disappear; the amphibians would remain—and the salamander would grow big like an alligator and turn into "Eryops"; fish, locusts, and clams would remain much as they are. And the green slime would stay put on the stagnant waters.

In some such way we might in time teach ourselves to read—first-hand—on the out-of-doors horizon—the genesis of the Appalachian forest. In this we would have to borrow from the research of the centuries. Our amateur collectors might arrange for us a rough genealogy of the forest species by graphic restorations of the departed ancestors, and in this way bring back the forest as it looked and lived in the stages between the carboniferous and now.

But to get the total story we should

have to look behind the carboniferous—which dates back only a quarter of the span that made the forest—and the living world. Our next stop might be in the Silurian Age (almost halfway back). The landscape of that day we should find a desolate thing: mountains there are and clouds and rains and streams and weathered soil, but a lifeless continent except along the shore; here we find the seamoss—the start of life upon the land, a plant life only, the crude low ancestry of moss and fern; but on the tideland, the tiny thread where continent and ocean overlap, we find the pioneers of landward animals in the like of snail and worm; all else belongs to water—sponge, squid, starfish, clam—and green slime the eternal in the stagnant pools.

Then go back twice as far again—to the Eozoic Age: Land only, and "igneous," no "manufactured" kind; no ocean, only a film of wetness; no atmosphere except a heavy carbonated film with thick winds and drippings as of rain; the planet's surface lately molten and just cool enough to let steam liquefy in spots. And with moisture—vitality: bacteria somehow come—and the green slime.

One more pursuit to get acquainted with the scenery: to trace the genesis of primeval life—and know that when the vital spark lights up in you it belongs not to you but to the ages.

To Read the Primeval

We have had a look at the Appalachian range and the forest on its slopes. We have surveyed them at long sight, and also in close view—in panorama and in cross-section. We have looked out and looked in. We may also look up—and thereby scrape some crude acquaintance with the stars, and with our nearby cosmic neighbors, the sun and moon and planets. We have obtained some notion perhaps of how to go about the pursuit of learning how to read, from the Appalachian Trail, to open book of primeval nature.

It is just a matter of putting this and that together. Let us continue to collect our specimens—of rock and mineral; of leaf and bud and fern and flower; of bird and skin and snake and bug: but let us weld them into some comprehensive whole through the disclosing medium of imagination. In this way only can we read the story that lies about us; thus only may we reveal (as would the radio) the harmonies and secrets which make our unseen world. It is a method as old as Aristotle. Thereby have we become endowed with the colossal and overwhelming tale of nature's simple processes found (and lost alas) in the myriad printed scientific treatises that fill our libraries. To the single specialist a single story comes to be known by heart—with or without its full appreciation. To the rest of us—we average numskulls who pace the earth—comes in any landscape a cataclysm of age-wrought deeds which so far transcends our understanding that our appreciation and the joys thereof are whittled down to grunts and exclamations. The young collector with his bugs and minerals secures the elements of nature's puzzle picture—and learns thereby his separate "ABC's"; but not until he fits them each in place does he learn to read the "open book" itself.

To learn to read—first-hand—on the horizon and along the stream—the big outlines of the primeval drama; to take specifically the Appalachian country as the common school and playground; to weave together the threads containing the total story of this country (even as already we have woven the separate sections of our total footpath): this appears to be the logical second stage for the second decade of our enterprise. A "pursuit" such as this to become acquainted with our scenery should be the next step in developing the Appalachian Trail.

VARIABLE STARS

By Dr. L. V. ROBINSON
ASTRONOMER, HARVARD COLLEGE OBSERVATORY

THE layman who has casually observed that the Big Dipper is always a dipper regardless of its position in the sky may also have noticed that all the stars appear to keep the same positions relative to one another. In general, the only exceptions are the planets. The layman, from somewhat hurried glances, may also be inclined to think that all the stars remain unchanged in brightness. If he could observe the stars a few thousand years hence, however, he would be convinced that "the stars do move," and a few days or weeks of continuous observation would also show changes in brightness of many of the brighter stars. The sun shares the motions of the other stars; in fact, it is dragging our little earth through space with a velocity of twelve miles per second relative to the other stars; but we move at a very slow rate compared with some of the suns, which are so far away in space that we call them stars.

The reason why the stars do not appear to move is that they are so exceedingly far away. Even the nearest is 275,000 times as far away as the sun is from us (that is, $275{,}000 \times 92{,}900{,}000$ miles), and light from this star does not reach us until it has been on its journey four and one third years. Light from the sun reaches us after a short journey of only eight minutes. By way of contrast, it is said that the sensation of a burn travels so slowly, relative to the speed of light, that an infant with an arm long enough to reach the sun would live his allotted time of three score and ten years and die in ripe old age before learning that his fingers had been burned.

But what of the brightness of all these far-away suns? By actually measuring their distances, astronomers can compare the brightness of each one with that of the sun. The intrinsically brightest star now known is one that is apparently associated with the great Magellanic Clouds of the southern sky. This star, called S Doradus, is not only important because of the fact that at times it is half a million times as bright as our sun, but also because it represents one class of stars known as "variables," on account of their variation in brightness. Among the variables, S Doradus is probably related to the sub-class which the astronomer calls novae.

Within the earliest records of man the first star observed to vary in brightness was indeed a nova in the constellation Scorpius and was discovered by the Greek astronomer, Hipparchus, 134 years before Christ. This star, which appeared very suddenly as a dazzling bright object where one had not before been seen, aroused the curiosity of Hipparchus and undoubtedly prompted him to compile the first catalogue of star positions, by reference to which the appearance of any new star, or the disappearance of any of those which he had already observed and catalogued, could be established.

The outstanding peculiarity of novae is that they manifest a sudden outburst in brightness and then gradually fade away, becoming invisible to the unaided eye after a few weeks. The second known star of this kind, a nova in Cassiopeia, was observed first by Tycho Brahe, a Danish astronomer, in 1572. When Tycho first saw it, this star was among the very brightest in the sky; within a few days it grew still brighter so that it could be seen even in daytime without the use of a telescope. When

the planet Venus is at its brightest, it is possible to observe it in the daytime, provided we know in what part of the sky to look, but Tycho's star is said to have been even brighter, notwithstanding the fact that Venus approaches us as closely as 26,000,000 miles, whereas most novae are probably hundreds of millions times as distant.

In recent years a more careful watch has been kept over the stars; in fact at Harvard, the whole sky is photographed many times in the course of a year's work. Also more people know the constellations and recognize very quickly the presence of any new bright star where previously none had appeared. As a result, known examples of novae have increased fairly rapidly in recent years. The brightest of the recent ones appeared in 1918 in the constellation of Aquila. In less than a week the normal brightness of this star increased nearly 70,000 times, and on June eighth it was exceeded in brightness by only one other star, Sirius.

With the instruments now at the astronomer's disposal, he is able to detect the presence of gases rushing out from these stars with velocities as high as 1,200 miles per second. We are led to conclude, therefore, that the great increase in brightness of these stars is due to an increase in diameter caused by some kind of explosion. The frequency of these explosions suggests to us that possibly similar disturbances occur within every star, at least once in its lifetime. If so, what warning are we to have of the approach of an explosion of the sun? The sun is only a star among the thirty thousand million others which astronomers believe are in our Milky Way system. Why then should it be the exception to the other stars? What if it should explode? We frequently see spots on the sun large enough to hold our little earth; we might therefore be justified in concluding that in a solar conflagration, similar to that which apparently takes place in a nova, the earth would disappear almost instantaneously.

As a representative of a second type of variable there is none better than Mira, the Wonderful, a star in the constellation of Cetus, which changes continuously in brightness, reaching a maximum and minimum periodically. Mira was first seen by the Dutch astronomer, Fabricius, in 1596; it appeared as a star of moderate brightness where one had not previously been seen. In a few weeks it had faded away and it was therefore thought to be a nova, until the year 1638 when it was seen again by another Dutch astronomer, Holwarda, who observed that it appeared and disappeared within a period of about eleven months. To the telescopic observer this star does not actually disappear, but when it is faintest it gives only about one per cent. of the visual light which it gives when it is brightest. Since the time of Fabricius and Holwarda, the number of recognized stars of this type has increased, especially during the last few years, until now our catalogues contain about two thousand other examples.

All of the stars of this type are more or less red and appear to be among the coolest stars in the sky. In their outer layers at least, they apparently vary in temperature and in color as well as in luminosity, but the highest temperature exhibited by a variable of this type never exceeds that of a very hot furnace, while many of the blue stars show temperatures ten times as high. Among the giant stars, in general, low temperatures and large diameters are very closely correlated and are thought to be characteristic of the earliest stages of a star's development. The enormous size of Mira is illustrative, probably, of all long-period variable stars. If the sun were placed at the center, inside the body

of Mira, and the distance (92,900,000 miles) between the sun and its companion the earth were unchanged, the earth would be several million miles below the surface of the star. Not only the earth, but Mars, which is 50 per cent. farther away from the sun than the earth, would be beneath the surface of this giant star.

At the level, which we call the surface of Mira, the constituent gases are much rarer than those composing the atmosphere of the earth, fifty miles above its surface; in fact they are in a rarer condition than can be duplicated by exhausting the air of a vessel with the best air-pump yet constructed. The rarity of the gases at the surface of this star is due to the smallness of the gravitational pull which varies inversely as the square of the diameter. A man weighing 200 pounds on the earth would weigh less than four ounces at the surface of Mira, were it possible to weigh him with spring balances in each case. On the small dwarf star circling about Sirius, by way of further contrast, this man weighed by the same method would weigh no less than 3,000 tons, whereas on our sun he would weigh only 5,500 pounds, or somewhat less than *three* tons!

In many ways the class of variable stars to which Mira belongs, ordinarily called long-period variables, is closely related to another type known to astronomers as Cepheid variables. The earliest observed type of this class is Delta Cephei, discovered by Goodricke in 1784. These stars are not so red as the long-period variables, and their periods of variation extend from a few hours to about seventy days, whereas the periods of long-period variables range from about 100 days to about two years. Furthermore, the range of variation in brightness is, in general, much less in the case of Cepheids than in some Mira-type stars where the brightness at maximum is 50,000 times that at minimum. Astronomers believe, however, that Cepheids are related to long-period variables because a correlation between redness and period, which has been noted among Cepheids, can also be extended to the long-period variables. The Cepheid variables and those of long-period are generally believed to be pulsating—that is, both classes may owe their changes in brightness partly or wholly to periodic expansions and contractions of the gases composing them. There are some astronomers, however, who believe that the variations in luminosity of the Cepheids are due to rotation and to their peculiar shapes. It is claimed that they are pear-shaped and eventually break up into two stars. Each theory has its objections, and much more work remains to be done before the matter can be considered as settled. (Fig. 1.)

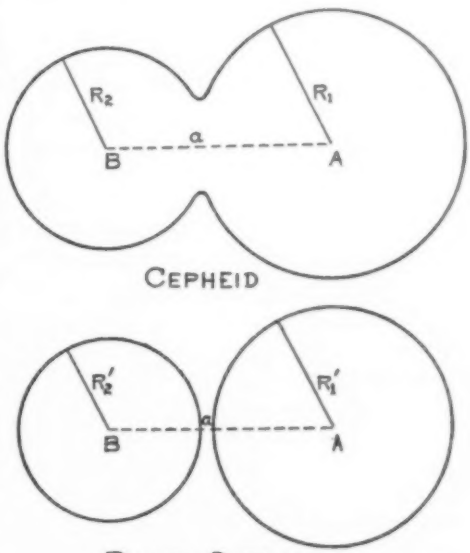


FIG. 1. ACCORDING TO THE JEANS THEORY,

THE TRANSITION FROM THE CEPHEID STAGE MAY BE THE RESULT OF CONTRACTION. THUS R_1 AND R_2 DECREASE TO R'_1 AND R'_2, RESPECTIVELY. IN THE FIRST CASE THE SUM OF R_1 AND R_2 IS GREATER THAN THE DISTANCE FROM A TO B, AND IN THE SECOND IT IS LESS.

The question, "What are Cepheid variables?" is hardly more interesting than the question, "What are they good for, astronomically?" In fact, solving the latter question has served astronomical advancement to a far greater extent probably than any other research which has been pursued in many years. It happens that in certain star clouds and clusters many Cepheid variables are found. In studying the variables in the Magellanic Clouds, Miss Leavitt, at Harvard, discovered that a relation exists between the periods of variation and the apparent brightness of these stars: the longer the period, the brighter is the star—the so-called period-luminosity relation. Since all the stars in the Magellanic Clouds are at very nearly the same distance from the earth, it can also be demonstrated that a relation exists between period and *actual* or *absolute* brightness. In other words, if we know the actual brightness of one Cepheid variable, then we can compute the distance of any other star of this type, once its period and apparent brightness are known. This is equivalent to saying that we must know the "zero point" of the period-luminosity relation in order to use it effectively. The zero point is determined from the apparent motions of the stars, since those nearest to us appear to move the fastest; hence the distance and therefore the brightness of an average star may be known. (Fig. 2.)

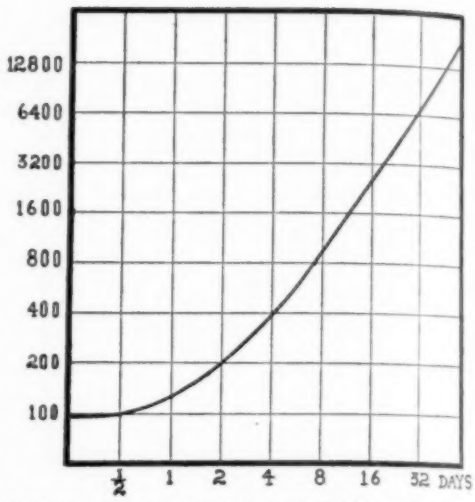


FIG. 2. THE PERIOD–LUMINOSITY RELATION.

HORIZONTAL AXIS IS PERIOD IN DAYS, AND VERTICAL AXIS IS INTRINSIC LUMINOSITY IN TERMS OF SUN'S BRIGHTNESS. THE ZERO POINT IS FIXED WHEN IT IS KNOWN, FOR EXAMPLE, THAT THE AVERAGE CEPHEID WITH A PERIOD OF TWO DAYS IS 200 TIMES AS BRIGHT AS THE SUN.

The period-luminosity relation proved to be the key that unlocked one of the secrets of the universe. The key was immediately seized by a young astronomer at Mount Wilson Observatory, and soon we knew the distances of all the far-away clouds in which the telescope revealed the presence of Cepheid variables whose periods could be determined. This young astronomer was Dr. Harlow Shapley, the present Director of Harvard College Observatory.

The enormous brightness of Cepheids favors their use as yardsticks in measuring the size of the universe. The faintest of these stars, the so-called cluster-type Cepheids, are intrinsically more than a hundred times as bright as our sun; consequently one of these stars can be seen when it is more than ten times as far away as a star of the brightness of our sun. The brightest representatives of the Cepheid class, which are about 10,000 times the brightness of the sun, can be seen at vastly greater distances. The huge 100-inch Mount Wilson telescope shows stars which give less than one millionth the amount of light of the faintest stars visible to the unaided eye, and consequently with it one sees stars over a thousand times more distant. In fact, Cepheids on the outskirts of our universe and among the great star clouds of the Milky Way system are visible in the Mount Wilson telescope. The farthest cluster of stars measured by Shapley was so far away that light received from the members was over 200,000 years old; or, the

cluster is said to be 200,000 light years distant. In the opposite direction, clusters were observed at distances of the order of 100,000 light years. For the first time in the history of astronomy investigators could say definitely that the universe had been sounded, and that its diameter was so large that 300,000 years were required for light to traverse it. Yet only a short time later, Hubble, at Mount Wilson, began to count variable stars, such as Cepheids and novae, by the dozens in the Andromeda nebula, identifying it as a great collection of stars, sometimes called an "Island Universe." He was able to measure distances more than three times as large as those previously determined. From this great collection of stars, which to the unaided eye appears as a hazy spot in the sky, nearly one million years is required for light to reach us. Some idea of the distance of this far-away cloud of stars can be gained when it is recalled that light from the sun reaches us in only eight minutes. (Fig. 3.)

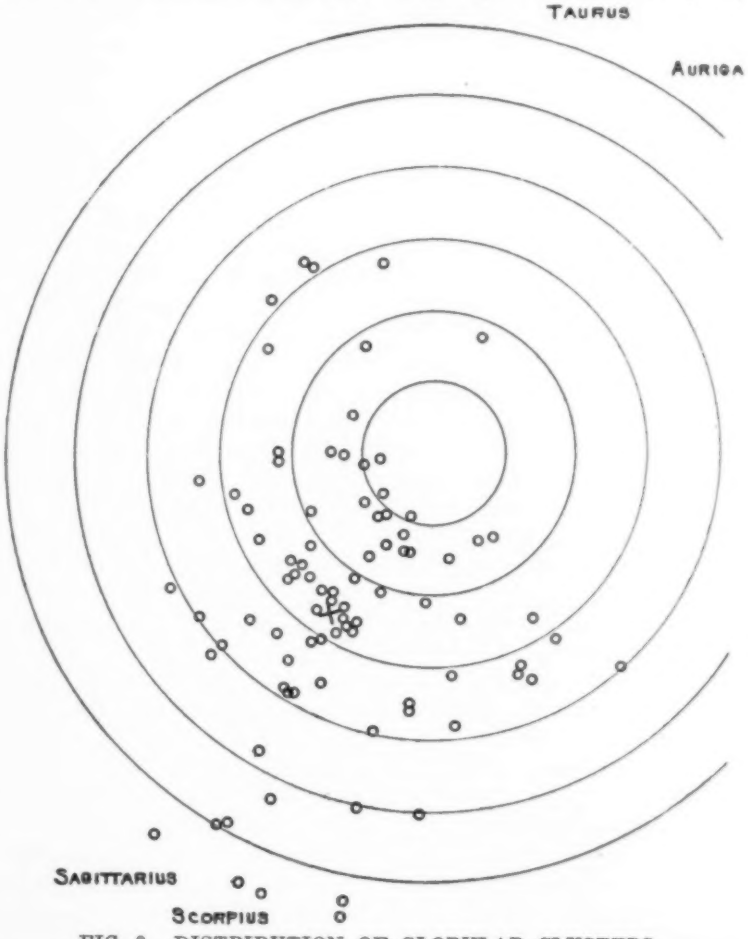


FIG. 3. DISTRIBUTION OF GLOBULAR CLUSTERS.

PLANE OF PAPER IS PLANE OF MILKY WAY; LARGE CONCENTRIC CIRCLES REPRESENT DISTANCES FROM SUN (AT CENTER OF DIAGRAM), THE UNIT BEING 25,000 LIGHT-YEARS; THE CENTER OF THE MILKY WAY SYSTEM IS REPRESENTED BY A CROSS. SMALL CIRCLES REPRESENT GLOBULAR CLUSTERS; FARTHEST CLUSTER IS TOO FAR AWAY TO APPEAR ON THE DIAGRAM.

The variable stars hitherto discussed are all intrinsically variable and in this way differ from the class of objects represented by Algol and Beta Lyrae. Algol, or Beta Persei, may have been recognized as a variable by the Arabs, since it was called by them *al Ghul*, or the demon, possibly on account of its apparent capricious drops in luminosity. The first historical evidence of its variability, however, seems to rest with Montanari, who noticed its variability in 1669, without attempting any careful study of the star. It was observed again in 1782 by a young Englishman, John Goodricke, a deaf mute, who not only determined its period of variation but also correctly suggested the cause. Beta Lyrae was discovered two years later by Pigot, a friend of Goodricke. Each of the two systems just mentioned owes its variability to periodic eclipses by the component star. In the case of Algol, one of the components is faint relative to the other, which is called the primary, whereas in the case of Beta Lyrae both components are approximately of the same brightness and relatively much closer together than the components of Algol. In fact, for many systems of the Beta Lyrae type, the components, which are generally of the same brightness, are very nearly in actual contact. The range of periods of eclipsing stars, including those of the Algol and Beta Lyrae types, agrees very closely with the range of periods of Cepheids. The amount of change in brightness is also about equal to that of Cepheids. For eclipsing stars, the amount of change depends upon the relative brightness of the two components of the system and upon the orientation of the plane in which they revolve to the line of sight.

It is clear that eclipsing stars constitute a very special selection among double stars: they are those systems where one star passes in front of the other and cuts off a part or all of its light, in much the same way that the moon cuts off the light of the sun when a solar eclipse occurs. They constitute only a part of those close doubles which to the unaided eye or in the telescope appear as single stars. There are other systems whose components revolve in planes so oriented relative to the line of sight that no eclipse can occur. These are the spectroscopic binaries, the duplicity of which is revealed from analyses of the light received from them by means of the spectroscope. Still more complicated are those systems which the telescope shows as double or multiple, where one or more components of the visual system are in reality spectroscopic binaries. Thus, the astronomer is able to discover that what appears as a single star to the unaided eye is in some cases a complex system of stars revolving about their centers of gravity, with periods from a fraction of a day to hundreds or even thousands of years. Such a system is Castor, the fainter member of Gemini, the twins. In this instance the telescope shows two bright stars exceedingly close together where the eye only sees what appears to be a single star. These two stars revolve about each other with a period of about 350 years. The third and fainter member of this same system is found a little farther away revolving about the common center of gravity probably with a period of more than a thousand years. Each of these three stars is a spectroscopic binary, so that in reality we have six stars belonging to a system where the unaided eye would see a single bright star. It is estimated that of all the stars in the sky, one of every three or four is a double or a multiple system. This is only one bit of evidence suggesting gregarious tendencies among the stars.

Astronomers believe that the distinction between visual telescopic double stars and the class of eclipsing and spec-

troscopic binaries is more real than apparent. Members of the former class have periods measured in years while those of the latter class, with a few exceptions, have their periods restricted below a hundred days. But why the difference? This is one of the questions of modern astronomy. Unless the universe is very much older than we believe it to be, near approaches and captures are not frequent enough to account for the large number of visual and telescopic doubles even if, under such circumstances, captures are possible. Serious doubts indeed arise if we assume that capture of one star by another may result from near approach. Probably the best suggestion is that visual doubles result from condensations about two separate nuclei in an early nebular stage of evolution. The revolution of one star about another, with reference to spectroscopic and eclipsing binaries as well as to visual doubles, is not more strange than the much more general fact now established by modern astronomy, that all the stars of the Milky Way system are revolving about their common center of gravity. To carry this idea further, it must also be concluded that visual and telescopic binaries were formed at a time when the Milky Way system was yet young and when all the stars were closer together than at present. At least we now see no evidence of the formation of such systems.

The question of the origin of eclipsing and spectroscopic binaries, according to some astronomers, has a close connection with the question of interrelationships of the different classes of variable stars: Jeans has proposed the theory that all variable stars are rotating and that when the period of rotation becomes sufficiently rapid, as in the case of the short-period Cepheids, the stars can no longer hold themselves together—an hypothesis known as the fission theory. If then a Cepheid is the parent of a binary system, how are we to prove it? Astronomical questions rarely lend themselves to direct proof, unfortunately, but any clue serves as a valuable bit of evidence either for or against a theory in question. We have evidence for extending the connecting links between long-period and Cepheid variables to eclipsing and spectroscopic binaries as well. We may mention: (1) there are spectroscopic evidences indicating rotation of Cepheids about their respective centers of gravity; (2) the mean densities of Cepheids are approximately what we should expect of two embryo stars in actual contact; (3) the mean radii of Cepheids compare favorably with the separation of the components of short-period binary systems; (4) slight evidences of correlations of colors and brightnesses of short-period binaries with Cepheids are to be found; (5) the agreement of periods is as good as can be expected, and (6) the space distributions of the two classes of objects compare favorably. These are necessary conditions substantiating the Jeans theory but they are not sufficient; they *prove* nothing. Arguments against the theory are also serious an.. difficult to meet. About the only alternative left for the fission theory proponent is to ask: What *are* the ancestors of this class of binary stars? Equally well may one ask the same question with regard to all double star systems. For the visual and telescopic doubles, however, the above conditions are neither necessary nor sufficient, and by no one is any relationship claimed between these stars and any class of variables.

In our own galactic system the total number of known variable stars given by the 1932 edition of Prager's catalogue is 5,461, about a large percentage of which nothing is known. A relatively large percentage of the remainder belong to classes of irregular or semi-

regular stars which may be intermediate between the various classes of periodic variables. We know practically nothing about these stars, since they demand series of observations more continuous than those now available. It is quite possible also that continuous series of observations made on all classes of variables would shed much light on the peculiarities and the causes of their variations which have hitherto escaped our attention.

Not only the professional astronomer but the amateur, likewise, can assist in answering astronomical questions. The part of the amateur astronomer is most strikingly manifested by the great work of the American Association of Variable Star Observers, composed of about 350 members working in this country and abroad, who in the course of a year report more than 25,000 observations on variable stars to its recorder, Mr. Leon Campbell, of Harvard College Observatory. By this organization more than a third of a million observations have been made on 500 variable stars, mostly of long period, and for the peculiar variable SS Cygni not a single maximum brightness during the last 35 years has escaped their notice. Besides this enormous program, a huge amount of variable star work is done at Harvard College Observatory by temporary employees who have other lines of activity and who do not claim to be professional astronomers. The field is a large one, and thus far we believe that we have done little more than penetrate the surfaces of the associated problems.

CYCLONES IN CONTINENTAL BATH TUBS

By EVALD ANDERSON
LOS ANGELES, CALIFORNIA

THE old-fashioned European bathtub, with its outlet or drain in the exact center of the bottom, is perhaps not the most convenient type for the daily or Saturday night ceremony, but it does provide excellent opportunities for observations on cyclonic motions in water. The most striking thing about such vortex motions in water is their similarity in appearance to atmospheric cyclones, and it would seem to the amateur observer that a careful study of such easily arranged water-cyclones might well give valuable data for the meteorologists.

Nearly every one is no doubt familiar with such vortical or cyclonic motion in water, but perhaps not very many have attempted to make any systematic observations. The first thing which is impressed on the observer is the large rôle that chance seems to play in such vortex motions. The direction of rotation, for example, though apparently mostly following that of atmospheric cyclones, *i.e.*, contrariwise to the earth's rotation, may be first one way and then the other, under apparently identical conditions; and the same haphazardness seems to prevail in many other respects.

The starting point of such vortex motions seems, curiously enough, to be the upper surface of the water. With a light directly overhead, the first evidence is a small circular shadow cast on the bottom, from the moving surface layer. Then the familiar "cyclonic cone" begins to form and deepen, until it finally reaches the bottom and outlet. It is then very easy to impart a to-and-fro motion of the water and simulate, almost exactly, the motion of a cyclone over the surface of the plains.

In this manner it is easy to see the reason for the absence of cyclones in hilly regions (assuming of course that such observations on water are applicable also to air). Thus if the lower tip of such a vortex, moving over the lower surface, strikes a projection protruding but a little over the bottom, the vortex motion is immediately destroyed.

In the particular case where most of these observations were made there seemed to be a close relation between the depth of the water layer and the probability of the formation of cyclonic motion. Except when initiated artificially this motion hardly ever started with a layer deeper than nine inches, but practically always started immediately if the layer was of half that depth.

As already stated, the direction of rotation is probably "counter earthwise" when not influenced by other factors. It was always so in one case, though subsequent observations elsewhere cast some doubts on the correctness of such a generalization. It is rather startling that confirmation of the rotation of the earth can be had by such homely means.

Vortex motions in water are naturally of great interest to the hydraulic engineer, and have also been made use of in the study of the flow of gases, but the only reason for discussing these particular amateur observations is their possible bearing on the study and prevention of atmospheric cyclones.

One might assume from such observations that a necessary condition for atmospheric cyclones is the existence of a fairly quiet layer of air with low pressure near the earth's surface and a similarly quiet layer of high pressure some distance above the earth. These

conditions can, of course, be brought about by reradiation of long wavelengths from the earth's surface to the adjacent gas-layer. It is well known that such layers of a heavy fluid over a lighter one can persist for appreciable periods. Nearly always these layers will probably in most cases finally mix more or less quietly through convection, but occasionally there might be formed something like a hole in the intervening layers, permitting the heavier air above to stream downwards to the region of lighter air below. Such a downward motion is then easily converted to the vortex motion. When then this intervening layer of air with its "hole" is moving over the surface of the earth we have the familiar cyclone cutting its path across the plains.

If the above picture is at all correct, it should be possible to devise methods for the prediction and perhaps prevention of disastrous cyclones. Assuming that it could be proven that a minimum pressure difference or a minimum height of a heavy air layer is necessary before such a cyclonic stream can start, then measurements of the atmospheric pressure and temperature at different levels during the cyclone season might produce useful data for such prediction.

But even though reliable prediction could be developed the ultimate aim must of course be prevention. We are perhaps too prone to assume that interference with such natural phenomena is impossible. Considering that only a slight projection from the bottom of a vessel of water suffices to stop cyclonic whirls in this medium, it might be possible to erect "cyclone walls" around the towns on our plains instead of cyclone cellars under them, for it is conceivable that such man-made obstructions of only moderate height would serve to protect adjacent lower structures. Furthermore, an observer of such motions must be impressed with their great instability since seemingly slight disturbances often suffice to entirely destroy the vortex motion, even though the downward motion persists. That being so it might be possible to so disturb an actual atmospheric cyclone as to stop the vortex motion long enough so that the disturbance can pass over a city without doing serious damage. For example, it would be interesting to try the effect of the modern explosive gas-shell on the tip of a cyclone, and it should be possible to devise a shell which could be exploded in the air without damage to the country below. Should such a scheme prove practical the fire-departments of the cities in our cyclone regions might ultimately have artillery brigades that would go out in defense of their towns when a cyclone approached. It is reported that such cyclonic disturbances on the ocean, commonly called water-spouts, have been destroyed by gunfire from warships so that there would be precedence for using artillery on land for this purpose.

The cyclonic disturbances herein discussed are naturally the minor ones commonly called cyclones or water-spouts. When we consider the larger atmospheric cyclonic motions commonly called "lows" where the average radius of the path of the moving air at the surface of the earch is measured in miles, the conditions are, of course, entirely different. These disturbances are, as a matter of fact, not broken up by the ordinary size obstructions, since those coming from the Pacific Ocean appear to pass over both the Coast Range and the Sierra Nevada Range without diminished activity. However, if some means of prediction and prevention of the smaller cyclones could be found, the gain in safety and comfort of the dwellers of the plains might still be enormous.

WASHINGTON SETS A RIVER ON FIRE

By Dr. NORMAN J. HARRAR
WASHINGTON AND LEE UNIVERSITY

A MEMORABLE experiment was carried out during the evening of November 5, 1783, on a little river north of Princeton, for with it is associated the name of George Washington. The first feeble attempts to employ scientific methods in those early American days are of interest to the historian but this particular story has a far wider appeal.

Any description of this experiment should be preceded by an account of the fortuitous series of events which led to its performance.

The summer and autumn of the year 1783 brought happy days to the commander-in-chief of that first American Army. Active military operations had practically ceased after the decisive victory at Yorktown and peace negotiations had long been in progress. A remarkably complete attainment of the dreams of independence was soon to be realized. This full achievement of purpose must have been a source of peculiar satisfaction to the tired general.

Late in the month of June of this year, owing to an unpleasant attitude on the part of some of the troops, Congress had rather hastily moved from Philadelphia to Princeton. In the seclusion of this quiet little town, deliberations continued upon the treaty of peace. About the middle of August, Washington was asked to come to Princeton to advise upon various details of the final terms. Acting upon this request, he left his army under the command of General Knox at Newburgh, and, with a portion of his military family, put himself at the disposal of the assembly.

A house was provided for Washington and his staff at "Rockingham," the estate of Judge Berrien's widow near the village of Rocky Hill, three or four miles north of Princeton. The dwelling was pleasantly situated upon an eminence, a few hundred yards east of a small stream known as Millstone River. These quarters were comfortable and conveniently located for the frequent contacts necessary with the sessions of Congress. In addition to the delegates engaged in the regular meetings, Washington entertained many persons of note during nearly three months of residence. He was able to relax somewhat from the long strain of work and worry, and by all accounts it was a most agreeable interlude.

Not so far away, but living under very different circumstances, was another leader of the independence movement, Thomas Paine. His writings had been of great importance in arousing the people of the colonies, and his services abroad had been equally valuable. Some of his friends had reminded Congress of its definite obligations to him, but he had gone almost entirely unrewarded. At the time, he was embittered perhaps as much by the unfairness of this neglect, as by the burden of real poverty. One day he received a heartening letter:

Rocky Hill, Sept. 10, 1783.

Dear Sir,

I have learned since I have been at this place, that you are at Bordentown. Whether for the sake of retirement, or economy, I know not. Be it for either, or both, or whatever it may, if you will come to this place, and partake with me, I shall be exceedingly happy to see you.

Your presence may remind Congress of your past services to this country; and if it is in my power to impress them, command my best services with freedom, as they will be rendered cheerfully by one who entertains a lively sense of the importance of your works, and who, with much pleasure, subscribes himself,

Your sincere friend,

G. Washington.

This friendly letter was entirely worthy of the great man who wrote it and naturally brought real happiness to Paine, who was only too glad to accept such a kind invitation. Thus it was that he journeyed to Rocky Hill, where he received a warm welcome and where he remained during the period of Washington's residence at that place.

A number of Paine's old comrades were there to greet him; among them were Colonel Humphreys and Colonel Cobb, who were at that time aides-de-camp to the commander, and also General Benjamin Lincoln. Apparently it was not long until Paine was in good spirits again because, true to his nature, he was soon involved in an argument.

It seems that the natives of the district had been amazing the officers with a peculiar story regarding the river or creek that ran so near to their quarters. The reports were that it was possible to "set the river on fire," to give the exact manner of speaking of these people. This was done, so they said, by disturbing the mud at the bottom of the river and then holding some blazing material, such as paper or straw, a little above the surface of the water.

Upon hearing this strange tale, Paine attempted to advance an explanation as to the cause of the mystery, and at once became entangled in a friendly argument with Colonel Humphreys and Colonel Cobb. The opinion held by the two officers was that, on disturbing the bottom of the river, some "bituminous matter" arose to the surface, which took fire when the burning substance was put to it. The theory developed by Paine was that a quantity of so-called "inflammable air" was set loose by stirring the mud on the river bottom and this ascended through the water and took fire as it left the surface. It seems that the truth of the reports about the river and the existence of some sort of combustible material was not questioned. Rather the dispute involved the nature of the peculiar substance, or more particularly, as to whether or not it existed in a gaseous form.

Apparently all this discussion aroused the interest of Washington, who made the sensible and practical suggestion that they all go down to the river and put the matter to a test. To quote the description written by Paine sometime afterwards, "General Washington had a mind to try the experiment." The necessary preparations were made by General Lincoln and everything was ready for the experiment to be tried out on the evening of November 5. The following description of this adventure is taken from a portion of the account written by Paine himself.

> A scow had been stationed in the milldam, and General Washington, General Lincoln, and myself, and I believe Colonel Cobb (for Humphreys was sick), and three or four soldiers with poles, were put on board the scow. General Washington placed himself at one end of the scow, and I at the other; each of us had a roll of cartridge paper, which we lighted and held over the water, about two or three inches from the surface, when the soldiers began disturbing the bottom of the river with poles.
>
> As General Washington sat at one end of the scow, and I at the other, I could see better anything that might happen from his light, than I could from my own, over which I was nearly perpendicular. When the mud at the bottom was disturbed by the poles, the air bubbles rose fast, and I saw the fire take from General Washington's light, and descend from thence to the surface of the water, in a similar manner as when a lighted candle is held so as to touch the smoke of a candle just blown out, the smoke will take fire, and the fire will descend and light up the candle. This was demonstrative evidence, that what was called setting the river on fire, was setting on fire the inflammable air that arose out of the mud.

It is evident that this experiment on the river gave results which supported the opinion that the combustible substance was in the form of a gas. However, mention should be made of the fact that the chemical composition of

this gas was unknown at the time, and the confusing term, "inflammable air," was being applied rather indiscriminately to various combustible gases. It was some years before the more specific name of "marsh gas" was generally used to designate the material tested in this experiment. Although certainly neither of them realized it, Washington and Paine were investigating the properties of a substance which had yet to be identified as the organic compound whose simple molecule is the basis of thousands of derivatives.

The experiment was not forgotten by Paine and he planned to follow it up with further research. Upon his next visit to Philadelphia, he described the results of these tests to David Rittenhouse, the scientist who succeeded Franklin as president of the famous American Philosophical Society. Together they continued the study of the properties of this "inflammable air," employing somewhat more exacting methods.

A report of all this work was finally published in a paper addressed to the "Board of Health in America," and entitled, "Of the Cause of Yellow Fever and the Means of Preventing It in Places Not Yet Infected With It." At this time there were frequent and severe plagues of yellow fever, the causes of which were not understood, although it was beginning to be recognized that there was some relation between the existence of marshy lands and the appearance of the disease. The theory advanced by Paine developed the idea of this relation and then attempted to trace the cause to various noxious emanations, particularly his "inflammable air," produced in swampy areas. Considering the amount of information available in his day, this opinion was by no means absurd. As a matter of fact, several noted authorities, especially Dr. Samuel L. Mitchill, and later, Alexander von Humboldt, famous tropical expert, suggested very similar explanations. Almost a century passed before any better solution of the problem was offered.

The experiment was probably not entirely forgotten by Washington, who had a most retentive memory for information of this nature. Just ten years afterwards, he might have thought once more about its relation to health and sanitation, for, about the middle of August of the year 1793, the capital city, Philadelphia, was visited by a terrible plague of yellow fever. He remained in the city for some weeks after most of the officials of the government had fled, but was finally persuaded to go to Mount Vernon.

The progress of the disease in Philadelphia was watched by the President with great anxiety, and his letters of this period are filled with the subject. He was particularly worried about the meeting of Congress, scheduled for December, and he considered the possibility of holding the sessions elsewhere. He expressed the hope that heavy rains would come, but it was the frosts of November that finally relieved the city. Naturally it is impossible to determine just how familiar he was with the current theories regarding yellow fever, but Washington undoubtedly understood the practical aspects of the situation.

The experiment made that November night should be remembered, even though the participation of Washington insures its fame. It was a simple thing to do, the results were not worth very much, they were even used to support a theory that turned out to be quite misleading. Nevertheless, there is something in the story eminently worth remembering. A certain characteristic attitude was brought out in the course of all the discussion and argument about possible explanations of the strange reports—"General Washington had a mind to *try the experiment.*"

SCIENCE SERVICE RADIO TALKS

PRESENTED OVER THE COLUMBIA BROADCASTING SYSTEM

SOME RECENT ADVANCES IN MEDICINE AND PUBLIC HEALTH

By Dr. G. W. McCOY

MEDICAL DIRECTOR, UNITED STATES PUBLIC HEALTH SERVICE, WASHINGTON, D. C.

WHEN Science Service assigned this subject to me it gave me a great deal of latitude as to the period of time that might be considered as "recent" in reference to progress in certain medical problems.

In a general way, I shall confine my remarks to advances that have been made during the last ten years, or, at least, to those that have received practical application within that decade. I shall omit any reference to surgery and medical specialties.

Progress in medical science is generally made in one or both of two ways: First, we have the careful study of disease in man by which we endeavor to discover the cause, means of prevention and mode of treatment by observation on the patient, study of his history, and of the effects of treatment. The second method you might speak of as the experimental one, in which the subject of experimentation may be man himself, or we may utilize the lower animals. A good example coming under the first head—that is, experimental work on man himself—is to be found in the observations of the great Jenner on the prevention of smallpox by vaccination. It was traditional in the country in which Jenner practiced medicine, for he was a practitioner in a rural community, that persons who had suffered from a particular disease of the hands derived from cattle did not take smallpox. Jenner put the truth of this tradition to the crucial test of experiment by inoculating a boy with cowpox and then, after a few weeks, inoculating him with smallpox material. The result was just as Jenner had expected it would be, the boy did not take the smallpox. Thus, by a single, simple, well thought out experiment on a human being the foundation was laid for a public health procedure which probably has done more in the way of preventing suffering and disability than any other one discovery in the field of preventive medicine, for you must remember that before Jenner's day smallpox was extremely prevalent compared with the present day and the death rate often was terribly high.

The second line of experimental attack on a problem involves the use of animals. I might give you many examples of this but I think one will suffice to illustrate the point. Through the means of experiment which involved the use of a good many dogs, the substance which we now know as insulin was found to have a very pronounced, beneficial, effect on diabetes. This substance is not regarded as a cure for diabetes but in many cases it does effectively control the symptoms and permit the individual to lead a useful life over a period of many years. To illustrate how well discriminating scientists think of this discovery for the treatment of diabetes, I may mention that the Nobel prize was awarded to Dr. Banting, whose brilliant experiments gave us this valuable remedy.

Finally, in this introduction, I should like to refer to the work of the late Dr.

Goldberger. His experimental investigation involved the use of both man and laboratory animals. I shall go into a little more detail in this respect a little later.

The order in which I shall consider some of the more recent advances is not to be taken as an indication of the relative importance of these advances. Some of the advances I am going to mention depend for their application on medical guidance by the well qualified physician. A few of them, however, deal with phases of subjects in which the person without medical training may profit greatly.

I suppose the most striking of the advances we have made is in respect to a comparatively rare disease, but one which proved invariably, or almost invariably, fatal prior to the studies of recent years. I refer now to pernicious anemia. Through a combination of very carefully designed experimental work on dogs and equally careful clinical work on patients, a most effective remedy for this disease was found in so commonplace a substance as the liver of animals that furnish us with meat for food. The physician now confronts the case of pernicious anemia with a feeling of the utmost confidence that he will be able to bring the condition under control. True enough, he will not be able actually to cure his patient but so long as liver, or one of its derivatives in the shape of liver extract, is available the symptoms can be controlled and the blood of the victim, which may have fallen to 20 or 30 per cent. of normal, may be brought back to the figure that is normal, or substantially so. So impressive are the results of the treatment of this hitherto incurable disease that one of the popular magazines awarded a prize of ten thousand dollars to be divided between Dr. Whipple, the experimental scientist who carried out the work on animals, and Dr. Minot, the skilful physician who carried out the bedside observations.

More recently another material has been found which is about equally effective with liver. This is the substance of the stomach of the hog. From the economic point of view this is a matter of some consequence because, as I am sure you all know, since the liver treatment of pernicious anemia became popular the price of liver has become quite high.

The progress in relation to the elements in food which we call vitamins is so rapid that one must specialize in this particular field to keep abreast of it. I shall refer to only one, the one that is of great importance particularly in the South. I have in mind now the vitamin the lack of which is responsible for the all too common disease called pellagra. The studies that led to the discovery of this fact—that is, that pellagra was due to the lack of a vitamin—illustrate the type of thorough research in praise of which one cannot be too enthusiastic. When Dr. Goldberger began his studies on the prevention and cure of this disease many physicians believed it contagious or infectious. The keen mind of Goldberger speedily saw that this question could be readily put to a test by dietary studies following two general lines: First, he sought to produce pellagra in volunteers by feeding a diet especially designed for that purpose, and succeeded in this. Next, he went to institutions in which pellagra was occurring with great frequency, and by suitable modifications of diet succeeded in wiping out the disease completely in those institutions. Then, to put the infectious theory to even a more severe test, but from a different angle, he tried to produce pellagra in volunteers, including himself and many of his friends, by the feeding of material from pellagrins, material which should have caused the disease in the volunteers if the disease could be carried from one person to another. He failed to produce pellagra in this manner. The results of the studies of this brilliant worker have been ac-

cepted without question by those competent to judge throughout the world, and pellagra has become one of the most readily controlled of all the diseases physicians and public health authorities are called upon to combat. That in practice it is not always controlled is due to dietary habits and economic conditions which will require a long time to remedy.

I cannot refrain from mentioning a by-product of Goldberger's work, a by-product which was not foreseen by anyone working on the subject. This was a discovery of tremendous interest to veterinary scientists and of the greatest value to dog fanciers and dog owners. I refer to the condition known to those familiar with the diseases of dogs as blacktongue. The cause of this was quite unknown prior to Goldberger's work. It was a malady that killed large numbers of dogs, especially in the South. This is a condition of dogs in many respects similar to pellagra of man. Goldberger proved that the cause was similar to the cause of pellagra, that is, that it was due to a diet deficient in some essential factor and that it was readily prevented and quickly cured by a suitable modification of the diet. If Goldberger's work on animals had failed us in respect to human pellagra, it would still be of enormous value purely from the viewpoint of the health of dogs.

I have just illustrated how a research designed primarily to control a disease of man has proven of inestimable value to lower animals. Now, let me give you the reverse of this:

Every one knows, I am sure, that the hookworms of both dog and man cause very serious conditions, often disabling the man, woman or child, and often killing puppies. Now, we have for a long time had fairly effective treatments for hookworms applicable both to dog and to man but they were far from perfect and did not always remove all of the worms; and, what was perhaps most serious, sometimes themselves proved poisonous to the patient, human or canine. Dr. Maurice Hall, of the Bureau of Animal Industry, approached this subject primarily in the interest of the dog, seeking to improve the treatment available for hookworms of that animal. His experiments were carried out on dogs and consisted of administering to individual dogs and to groups of dogs, various chemical agents which he hoped might prove effective. He found a more effective agent than any known before and it was soon found to be an improvement on the treatment of hookworm of man as well as of dogs. Many would have been content to stop there, but Dr. Hall is a true scientist and was unwilling to stop short of perfection, or as near perfection as he could attain. His work was therefore continued and another drug was found that was equally effective in curing the dog and safer for the patient. I tell this to illustrate why those interested in advancing the welfare of man and of animals continue experimental work even after progress has been made. I suppose the worst thing that could happen to medical and veterinary science and public health as it affects both fields would be to regard anything as permanently settled. We must constantly endeavor to improve the means already at our disposal for the prevention and treatment of disease.

The next subject is one that might be spoken of as a new disease, or, perhaps, a disease newly recognized insofar as concerns us in the United States. I refer to undulant fever, sometimes known as Malta fever—although this name is unsatisfactory because the disease prevails far beyond the borders of Malta. We know now it is tolerably prevalent in the United States, although a few years ago we knew nothing of it save that occasionally some one in the southwestern part of the United States was infected from goats. We know now that people often are infected by handling diseased swine or cattle. Sausage makers seem to be

especially likely to get the disease from handling the carcasses of hogs. One of the most controversial points in respect to this disease is as to just how far the infection is due to cow's milk. The evidence suggests that perhaps half of the cases we have in this country are derived from milk. The prevention of milk-borne undulant fever is quite simple: Use only pasteurized or boiled milk and there will be no danger. That this really works in practice is evident by the fact that in communities in which all milk is pasteurized the disease is unknown, while individual cases and small outbreaks occur when milk is not pasteurized. Of course, there are other good reasons for the pasteurization of milk; the risk of undulant fever is to be looked upon as an *additional* reason. The prevention of the cases not due to milk, those due to contact with infected animals or animal products, is unsatisfactory. It is encouraging, however, to know that veterinary scientists are steadily going forward in research in this important field and that we may look hopefully to the time when the disease in animals can be either abolished or brought under very definite control—and thereby the source of human infections will be eliminated.

I suppose one of the most important advances made in medicine within recent years has been with reference to the prevention of diphtheria by specific immunization. We have had for many years an effective treatment of diphtheria in the shape of antitoxin. The death rate was thereby greatly lowered but still the number of cases continues distressingly high. It is possible at the present time, through immunization of children, almost to guarantee that a treated child will not be attacked. In some communities in which diphtheria prophylaxis has been in use by health authorities the number of cases has been reduced nearly to the vanishing point. Physicians everywhere are now encouraging parents to have their children immunized before the school age since it is in the earlier years that diphtheria is the most prevalent and most frequently fatal.

I am going to conclude my remarks by referring to one of the most interesting and important pieces of work with which I am acquainted. For some years there has been occurring in the Eastern and Southeastern States an eruptive disease which was regarded as typhus fever, not quite so severe as the typhus long familiar to physicians as "camp fever," "jail fever," or "ship fever," but still essentially the same. On the basis of keen medical observation of patients and well thought out experimental work it has been shown that what we in the vicinity of Washington and adjacent territory were calling typhus fever really embraces two diseases: One, typhus proper and the other a disease that is identical with, or at least not to be distinguished from, the spotted fever of the Rocky Mountain region. Now this might be a matter of interest only to students of medical sciences but for the fact that the differentiation of the two diseases was accompanied by the throwing of much light on the modes of transmission. It has been shown that typhus, which in Europe is conveyed by the body louse, in this country probably is conveyed by fleas and possibly by other parasites. On the other hand, and this is very important, the indications all point to the Rocky Mountain spotted fever type of infection as being carried by ticks in our eastern states just as it is carried by ticks in the west. If further research confirms what now seems probable in regard to the sources of infection of these two diseases, we have in our hands easy means of prevention.

HUMAN VARIATIONS

By Dr. ADOLPH H. SCHULTZ
LABORATORY OF PHYSICAL ANTHROPOLOGY, JOHNS HOPKINS UNIVERSITY

THAT no two human beings look exactly alike is a well-established fact. Even in so-called identical twins one can detect many differences by exact and detailed comparisons. Thus, every man represents a variation, which means a deviation from the typical or average condition of the particular race to which he belongs. To be more precise: every individual represents really a special combination of many variations, since every part of the body can vary more or less independently. For example, if we study stature alone we can find many individuals of a series studied who do not differ from one another in this feature. If, however, we were to arrange this series according to stature *and,* let us say, chest circumference, the number of corresponding individuals would become much smaller. If, finally, we should consider twenty, instead of only two, bodily characters, it is most unlikely that any two individuals would show exactly the same variations in all the features examined.

What are the underlying causes and what the effects of this tendency of the human body to vary in all its parts and this frequently with surprising intensity? We cannot claim to have as yet found the final answers to these fundamental questions, but we have collected a mass of information on the nature of variations which is of great interest in itself and which at least points in the direction of an ultimate solution.

There exists a wide-spread belief that individual differences become more and more pronounced with advancing age under the direct influence of differing occupations, diets and other environmental factors. Such a view, however, agrees in no way with the facts observed. Anthropologists have long ago realized that all men are not born equal but differ from one another at least as much at birth as in adult life. Indeed, long before birth, when the body is less than an inch in length, one can already distinguish individuals with proportionately long limbs and slender trunks and those with relatively short limbs and stout trunks. Individual differences in the shape of the nose, mouth, ears, hands, and in other parts of the body are as clearly defined at early stages of development as at the completion of growth. We can not, therefore, hold environmental factors responsible for all these variations. This is also borne out by the finding that wild monkeys in their native jungle vary as extensively as do human beings under the diverse conditions of civilization. Among several hundred monkeys of one species, collected in the uniform environment surrounding one camp in the forest of Nicaragua, I found specimens with pug noses and those with straight profiles, some with large ears and others with small ones. In short, they differed from one another as widely as would an equal number of human city-dwellers and this in spite of the fact that these monkeys all had the same occupation, the same diet, and the same climatic conditions, etc., and this during thousands of generations.

With environment ruled out as the primary cause of human variations we have to examine the question whether heredity is the basis of them. It is not necessary to explain that many individual traits are readily understood to be the result of the combination of differing hereditary patterns in the parents. Heredity alone, however, will not explain

all variations. This is evident from a study of the exact mode of resemblance between single-ovum twins, who theoretically are endowed with identical hereditary qualities. If such twins are examined and measured with accurate instruments it is found that frequently they differ from each other very significantly, and this not only in adult life but also before environmental factors could have exerted a noteworthy influence, namely during their embryonic stages of growth. Just as twins, developing from the two halves of one and the same ovum, are often not alike, so are the two halves of the same body rarely of exactly corresponding size and shape. Such asymmetries are well known to exist in the length of the arms, the right one usually being longer than the left. This is commonly held to be a consequence of right-handedness, which is supposed to give a special growth stimulus to the right arm. However, asymmetries occur in practically all parts of the body and can be particularly marked in such structures, as the outer ears, which have no more function on the right than on the left, as has the hand. Furthermore, asymmetries, which really represent nothing but variations in the two halves of the body, occur in the apes as well as in man and are fully as pronounced in embryos as in adults. It is evident that heredity alone can not account for all variations, but it is known that many variations are transmitted by heredity. The universal tendency to form individual variations, that is to deviate from the average condition, must be regarded as representing *primarily* a force in itself, existing in spite of heredity and independently of environment, but either accentuated or subdued by the latter two factors.

It is most significant that different parts of the body vary with widely differing intensity. In the white race, for instance, the color of the skin varies not nearly as much as the color of the hair or of the eyes. The proportion between the lengths of the upper and of the lower limbs is not nearly as variable as the proportion between the length of the limbs and that of the trunk. The number of vertebrae in the neck region of the spine is constant with very few isolated exceptions, but the number of vertebrae composing the lowest region of the spine varies tremendously. Generally speaking, it can be stated that the more variable a particular structure the more it is apt to undergo possible changes in the future or to have changed during the past. On the other hand, comparatively uniform structures have little chance for new adaptations because they fail to provide new possibilities for selection.

In many structures we can recognize in the range of individual variations the trend of evolutionary modifications. To mention just one of many available examples: There exists abundant evidence for the conclusion that man once possessed a tail containing more vertebrae than have persisted in vestigial form to this day. The reduction in these vertebrae has not progressed equally far in all individuals, in some men six are still retained, whereas in others this number has already dwindled to four or even only three. The former case represents a primitive or retarded variation, the latter a progressive variation. In the orang-utan this evolutionary degeneration of the tail has reached an even greater extreme and the pendulum of variations has shifted, swinging no longer between six and three vertebrae, as in man, but between only four and one. In many instances it is impossible to give a plausible reason for the selective value of such variations. If we call some rare variation "primitive" just because it corresponds to the most common variation in an ancestral form, it does not necessarily imply that this condition has become disadvantageous to its present owner and might for this

reason become eliminated by one form of selection or another. Many, if not most, variations are in themselves entirely inconsequential to the individuals possessing them. Nevertheless some may gradually become eliminated, whereas others may appear with increasing frequency in later generations, not because they are "good" or "bad," but because they regularly happen to be associated with some other variation of a decidedly selective value. Such quite definite combinations of certain variations in morphological and physiological features are recognized as constitutional patterns. If such a pattern or type includes but one fatal variation, such as a high susceptibility to some disease, all the other, indifferent, associated variations will be carried along in the eliminating process of selective mortality.

It may bluntly be claimed that without variations there would be nothing to select from and without selection there could be no progress or at least no lasting change in, or evolution of, our physical make-up. A multitude of selective factors is continually at work among constantly occurring human variations. Some of these factors have lost their efficiency with advance in civilization, but that very advance has introduced new selective processes of sometimes very doubtful benefit to the human race. It is most essential that all these selections be carefully investigated so that we shall become able to place them under our control.

CROPS AND CIVILIZATIONS

By Dr. E. D. MERRILL

DIRECTOR OF THE NEW YORK BOTANICAL GARDEN

THE title of this article is a very comprehensive one, and within the limits of space available to me only certain aspects of the subject can be presented. There is, however, a distinctly interesting series of correlations which I shall attempt to summarize in this brief address. It is self-evident that agriculture is basic to all advanced civilizations. It is equally evident that all cultivated plants and all domesticated animals were derived from wild ancestors, some time during the development of the human race and, for the most part, early. We are apt to take our cultivated plants and domesticated animals for granted and seldom give a thought to whence they came, when, where and by whom the plants were brought into cultivation and the animals domesticated, how, when and by whom they were disseminated. The facts are in general approximately known, but the inferences to be drawn from these facts are too often ignored.

It is well known that practically every cultivated food-producing plant and all domesticated animals now found within the limits of the United States were introduced from other regions. Some years ago while residing in the Philippines it occurred to me that in that strictly tropical archipelago, covering a water area of approximately 600,000 square miles, the same statement was true; that all the cultivated food-producing plants and all domesticated animals now found in that archipelago were exotic, having been introduced in the past from various parts of the world, some in the prehistoric period, others within historic times. It was found that other very large areas in various parts of the world presented the same story. It gradually dawned upon me that here was a fertile field for investigation. In reference to the United States, the Philippine Islands and other large areas in the world the questions arise: Where

did these agricultural plants and animals originate? When, how and by whom were they introduced into the regions where they now occur? What limitations, other than climate, inhibited the universal distribution of important food plants and animals up to about 500 years ago?

It is well known that every important food-producing cultivated plant was already in cultivation and every important domesticated animal was already in domestication at the dawn of recorded history. In the agricultural experience, slowly built up by many peoples through the long period of pre-history, was laid the basis of all civilizations. It is, of course, axiomatic that before a civilization could develop anywhere, there must be a constant and dependable food supply, and this our remote ancestors insured during their long period of agricultural development. While modern man has accomplished much in plant and animal breeding, increasing quality and yield, and ensuring a more dependable food supply through breeding for disease resistance, yet after all it may be doubted if any modern development in plant and animal breeding equals the accomplishments of our very remote and uncultured ancestors who brought the very numerous plants and animals basic to agriculture in from the wild and developed them to serve their needs under domestication. It is rather strange that, in spite of the tremendous advances man has made in the past few hundred years, in this period, outside of numerous ornamentals, he has actually domesticated very few species of plants and no animals; and the few plants domesticated are not food-producing ones, but rather those which yield products in great demand in modern trade, such as *Cinchona* (quinine), *Hevea* (Para rubber), abacá or Manila hemp, and other medicinal, oil and fiber producing plants. The culture of many species has been very greatly extended, such as coffee, tea, cacao and numerous others, but these were all in cultivation many centuries ago, either in Eurasia or America, but none were known outside of the continental areas where they originated before the advent of European exploration.

If one surveys the world in relation to the places of origin of agricultural plants and domesticated animals, it becomes evident that vast areas originally produced nothing of consequence in the plant or animal kingdom as far as agriculture is concerned. Thus all North America north of Mexico, all Australia, much of Africa, and large areas in Asia, Europe and South America added practically nothing to our stores of plants and animals basic to agriculture. The centers of origin of the more important species are peculiarly restricted and, what is perhaps of even greater interest, these centers of origin of agricultural products correspond rather closely with those regions in which ancient civilizations were developed. A combination of favorable climatic conditions; native plants or plants and animals of importance in the production of food and that were more or less readily adapted to domestication as a basis of a permanent food supply; potential mental ability on the part of the local pioneers of civilizations; and, perhaps, fortuitous circumstances, all had their part in this period of pre-history, as far as man and his civilization is concerned.

The centers of origin of civilizations and of agricultural plants in America are in general two rather restricted regions with equable climates; the highlands of Mexico in North America, and of Peru in South America, with a more tropical subcenter in Central America and Yucatan; in Eurasia, Asia Minor, certain parts of the Mediterranean basin, and restricted areas in India, China and central Asia correspond to the few centers of origin in America. And what is again of distinct interest is that in these

centers of the beginnings of ancient cultures the independent civilizations were built primarily on the basis of certain definite plants and animals native of each region. Thus in Peru, the potato and various beans were basic; in Mexico, the most important food plant was maize, or Indian corn; in Asia Minor, and perhaps in some parts of the Mediterranean basin, the basic foods were our standard cereals, barley, wheat, rye and oats; and in India and in China, rice. In each center there were, of course, secondary food-producing plants, including various vegetables and fruits and in most or all centers certain animals were of distinct importance.

Without going into detail it is of interest to note in general the origin of basic agricultural plants and animals, as between the old and the new worlds.

The food plants of Eurasian origin are the common cereals, such as wheat, rye, barley, oats, rice, millet, Italian millet, sorghum, pearl millet and others of minor importance, such as ragi, teff and coix; in this category for convenience buckwheat may be placed, although it is not a true cereal; among the vegetables are the turnip, cabbage, rape, radish, beet, parsnip, carrot, onion, leek, garlic, shallot, spinach, egg-plant, lettuce, endive, salsify, celery, asparagus, pea, soy-bean, cow-pea, chick-pea, pigeon-pea, lentil, broad-bean, hyacinth-bean, asparagus-bean, taro and the yams; among the fruits are the apple, pear, plum, cherry, European grape, apricot, peach, prune, olive, fig, almond, persimmon, quince, pomegranate, melon, watermelon, cucumber, and in the warmer regions the banana, coconut, all citrus fruits, including the orange, lime, lemon and pomelo, date, mango, bread-fruit, jakfruit, rambutan, litchi, longan, lansone, mangosteen, and others. The domestic animals of Eurasian origin include all breeds of cattle, horses, water buffaloes, yaks, sheep, goats, swine, ducks, geese, hens and pigeons. These are the basic agricultural foods of the entire eastern hemisphere. Of course, many of them are limited in their range by climatic conditions, and from the standpoint of European civilizations, many of the plants that will thrive under European climatic conditions, and some of the animals, did not actually reach Europe until well into the period of recorded history; some were introduced in very modern times. The point I wish to make is that they are all natives of some part of the Old World and none were known in America previous to Columbus' voyage in 1492.

While the list of food plants and domesticated animals native of Eurasia is an impressive one, certain very important items are lacking; these are essentially the agricultural products on which the American civilizations were based. The basic food plants of American origin include but one cereal, but this is a very important one, maize or Indian corn; in addition, there are such vegetables as the potato, sweet potato, lima bean, all varieties of our common garden and field beans, tomato, pepper, Jerusalem artichoke, squash, pumpkin, quinoa, peanut, and in the more strictly tropical regions cassava, arrowroot, chayote and such fruits as the papaya, avocado, pineapple, custard-apple, soursop, cherimoya, sapote, sapodilla, cacao, cashew, and others. The domesticated animals were peculiarly few, the llama and alpaca in South America, and the turkey in Mexico. These are the basic agricultural products on which the American civilizations were based, and none of them were known in Europe or Asia previous to 1492, even as none of the longer Eurasian list were known in America before that date.

Various problems appertaining to ancient civilizations in America have intrigued many investigators, and numerous theories have been proposed to explain certain resemblances between these pre-Columbian American civilizations

and those of Eurasia on the basis of supposed contacts across the Atlantic and the Pacific. It is, however, a curious and incontrovertible fact that previous to 1492 not a single cultivated food plant of major, or even secondary, importance, or a single domesticated animal, except the dog, was common to both hemispheres.[1] Briefly, this means that agriculture was developed independently by primitive man in America strictly on the basis of American plants and animals and that the early American civilizations were developed on the basis of this agriculture. It is only within the past five centuries that there has been a general world-wide dissemination of the basic food plants and domesticated animals. The resemblances between the early American and the Eurasian civilizations are apparently only fortuitous. The conclusion that one draws on the basis of biogeographic distribution of plants and animals basic to agriculture is that there were no contacts of importance between Eurasia and America previous to 1492. Had there been in the long period of pre-history only fortuitous and accidental contacts, and these only at long intervals, after the development of agriculture, the first items to be transmitted across the ocean would be seeds and tubers of food-producing plants, that is, those items essential to the maintenance of life, rather than the more advanced arts of architecture, hieroglyphic writing, and political, civil and ecclesiastical organization. It is the history of primitive invading or colonizing peoples in such vast areas as Malaysia and Polynesia that they took their food plants with them in their migrations, just as at a later date Europeans colonizing America brought their familiar agricultural plants and animals with them, and established them in their new homes. It is certain that, had any considerable number of these agricultural items of Eurasia been transmitted to America before 1492, or *vice versa*, at least some of them would have persisted in cultivation in their new homes, so that when Europeans actually commenced the exploration of America they would have found somewhere cultivated food plants with which they were familiar at home. What they did find was an agriculture based on a series of plants and animals totally unfamiliar to them and for the most part representing natural groups (genera) different from those of Europe and Asia.

[1] The gourd, *Lagenaria vulgaris*, is the only cultivated plant regarding which we have incontrovertible evidence of ancient cultivation in both tropical America and tropical Asia and Africa before 1492, but this plant is of very minor importance from the standpoint of food. It was probably disseminated by ocean currents from whatever may have been its original home. There is some evidence that the peanut occurred in Africa before the European exploration of America commenced and, if so, it must have been transmitted across the Atlantic by man. Similarly, there is some evidence that the sweet potato may have been introduced into Polynesia by the Polynesians from America previous to the advent of Europeans in the Pacific basin, but the evidence is not very conclusive. Those theorists who have claimed the coconut to be native of America, and that the banana was in cultivation in tropical America before 1492, have based their arguments on totally inadequate evidence, and their arguments in each case have been most successfully refuted. In passing, it may be noted that tobacco is also native of America and was unknown in the Old World before Columbus' voyage, although here again at least one theorist has proved to his own satisfaction that tobacco originated in Africa, or that it was present in Africa before 1492, and others have made similar claims for New Guinea, at least to the extent that the practice of smoking tobacco originated independently in New Guinea on the basis of an indigenous species of tobacco. See E. D. Merrill, "Tobacco in New Guinea," *Amer. Anthropologist*, 32: 101–105, 1930, where this ethnological myth is explained.

SIMPLIFYING OUR CALENDAR

By Dr. CHARLES F. MARVIN

CHIEF, U. S. WEATHER BUREAU, WASHINGTON, D. C.

I AM here to tell you something about our present calendar, that is, the Gregorian calendar now in almost universal use throughout the world, and how it should be simplified. Only in Africa, Asia, and some islands of the South Pacific Ocean, primitive forms of ancient tribal and old national calendars are still in local use, often side by side with the Gregorian calendar. Conflicting differences between the feast days, holy days, work days, etc., by these different calendars are serious hindrances to the orderly progress of modern trade, business and industry in many cosmopolitan cities of India, China and the Far East. The world is now in need of a simple, uniform calendar that all nations can unite in designing, approving and using.

Nearly every one takes our old calendar as a matter of course, or assumes that it is quite perfect. A few even hold to an idea that it is of divine origin, and therefore that it is sacrilegious to meddle with or undertake to change it. A very brief acquaintance with calendar history, however, shows conclusively that all calendars are wholly man-made institutions and that ours is of purely pagan origin and design. It began with, or before, the founding of Rome. At first it was controlled in its operation by primitive minds who strove to make each month begin with a new moon, and, in addition, to have each spring time season, that is, the date of the equinox, fall about the 25th of March. Starting with Romulus, every effort to harmonize this lunar and equinoctial control met with repeated failure and called for repeated changes over many centuries.

The Emperor Numa, in order to maintain the ideals, added two new months, February to follow December and January to begin the new year. Later the Decemvirs shifted the month of February to its present position and made other changes, so that March would always remain the spring time month. All these efforts failed, and the calendar came into hopeless confusion by the time of the mighty Caesar, who abolished all idea of any moon control on the beginning of the months and gave the great Roman Empire its first nearly perfect calendar, controlled by the sun alone. He instituted the familiar quadrennial leap year rule. However, because this rigid rule of adding one day *every* fourth year added one day too many every 128 years, the date of the spring equinox slowly changed. Its date at the time of the great church Council of Nicea in 325 A. D., was March 21. By 1580 its date had changed to March 11.

The leaders of the Roman Catholic Church, especially, long deplored this slow shift in the date of the vernal equinox, because it involved a conflict with the church rule for fixing the date of Easter. At last Pope Gregory XIII decreed the faulty calendar must be reformed by striking out the 10 leap days added in excess between 325 A. D. and 1582, also that, in future, three century leap years in each 400 years must be non-leap-years. This is our present Gregorian calendar. Nearly 200 years elapsed, before England and its American colonies actually adopted the Gregorian reckoning. This was done in 1752, which was the first year in which New Year's Day throughout England and America fell on January 1. Prior thereto New Year's Day was dated March 25.

Finally, it is important that I tell you briefly how the present seven-day week came to find its place in the old Julian calendar. On the 50th day of the exodus from Egypt of the Israelites under

the leadership of Moses, among other notable events in their history they received the fourth commandment, directing them to work six days and keep holy the seventh. This command bound only the Israelites, not the Gentile world. However perfectly the Jews may have observed the Decalogue Sabbath every seventh day since the Exodus, there is not a scrap of valid historical evidence to support the irrational claim made by some religious sects that Sabbaths were observed in unbroken succession, long before the Exodus, back indeed to the very time of the creation of man, whatever that may mean to this enlightened civilization.

Furthermore, prior to the spread of Christianity westward over Europe, the week was not a part of the old Roman, or the Julian, or any other pagan or Gentile calendar. Not until the second and third centuries of the Christian era did the present week-day names begin to find a place in the calendars of Europe. Within that period these day names were then very gradually superposed upon the regular official Roman calendar. Strangely enough, this was brought about unofficially by the unopposed public usage of the seven pagan day names given to the seven days of the Christian week. Finally, the Emperor Constantine made this usage official by his edict of 321 A. D., which sanctioned Sunday as a day of rest.

These indisputable facts of history show that calendars belong to the people. They have been made and *changed* many times by imperial rulers or others in high authority. To-day the people themselves are the rulers and they can change the calendar whenever new conditions of civilization require.

Every change in this Roman calendar made in the past was to remove or overcome one serious defect. Numa, the Decemvirs, Caesar, Gregory, all strove to correct and prevent the incessant shifting of the date of the equinox. To them this was the great and intolerable defect of their calendar. No man in those distant ages was able to conceive how this might be accomplished. It remained for Lillius, the adviser of Gregory, to propose the simple leap year rule which effectually solved this calendar riddle of all those earlier ages.

For the past 20 years and more, Chambers of Commerce, scientific organizations, and many leading minds in all walks of life in many nations have been urging a further simplification of the Gregorian calendar, whose grave defects hinder the progress of social, scientific, economic and even the religious affairs of modern times. These matters have been formally considered by the League of Nations since 1924, and important conclusions were reached in an international conference held during last October, in which representatives from 44 nations participated.

Let us briefly analyze the more serious defects.

The wide fluctuation during different years in the date of Easter from March 22 to April 25, while not strictly a fault of the calendar, has by common consent been made a part of the movement for calendar reform. The fluctuations disturb the regularity of industrial, financial, commercial and judicial activities, including the maintenance of a normal plan of school and university studies. Although this is preeminently a religious question which depends upon the free decision of the Christian churches, nevertheless large sections of the various world population have expressed the almost unanimous desire that the date of Easter and dependent movable feasts be fixed or stabilized. The League conference in October was practically unanimous that the common good calls for the stabilization of the movable feasts and the League will submit the question to the churches for such action as they may decide to take.

There are really only two serious or major defects in the present calendar, both of which may be overcome by very simple changes. The first of these is commonly called lack of fixity, and is well illustrated by this New Year's Day. Today is the first day of the first month of the New Year, but it is Friday, the fifth day of the week. Next year New Year's Day will fall on Sunday, and the year after on Monday. This incessant annual change of day names and dates runs through all the months of the whole year and compels us to look up calendars whenever we wish to know the days and dates of periodical events, like Christmas, the Fourth of July, our anniversaries, and any important public event. This serious calendar defect can be quite overcome if we all agree to a simple change which makes January 1 of each year always a Sunday, for example. All that is required to attain this result is to give a new name, such as Yearday, to the very last day in each ordinary year. Since each non-leap-year begins and ends on a day of the same name it is plain that if the year begins on Sunday and the last day is named Yearday, the name Sunday is available to name the first day of the next year, indefinitely, provided the extra day added in leap years is given a non-week-day name, like Leapday. This simple change easily removes the serious defect of lack of fixity of the present calendar.

The second serious defect is the unequal length of the months, more especially that, with one exception, fractions of weeks now occur at the beginning or at the end of every month. The simple and easy solution of this defect is to make every month contain exactly four weeks, just like February in ordinary years. This requires a calendar of exactly thirteen 28-day months, year day and leap day being the 29th day to two of the months when required.

While no final decision was reached at the League Conference, chiefly because of the disturbed order of things and because the governments themselves have not as yet given the question sufficient study, nevertheless the defects of the calendar were clearly recognized, also that there is no reason for changing our calendar except to remove those defects. Therefore, *little* or *partial* changes advocated by some can not be favored because one or more of the major defects still remain and the *little* change works no real benefit to ourselves or our posterity.

Changing a calendar is a question of reason and common sense applied to a study of the intricate technicalities of the matter. Our sentiments and our conservatism, however, naturally incline us to resent, at first, any proposals for a change. Nevertheless, I hope that many who hear me will favor this important world movement which in this modern age must be attained through the force of public approval rather than by some imperial edict as sufficed in the past.

THE AMPHIBIAN IN ART AND LITERATURE

By Dr. S. W. FROST

THE PENNSYLVANIA STATE COLLEGE

IT is evident, from art and literature, that the frog and the toad were well known by the most ancient civilizations of the world. Long before the time of Christ, they were occasionally used in primitive art. The first semblance of an amphibian is an amulet of a toad, belonging to the period S. D. 39,[1] unearthed along the western bank of the Nile in the vicinity of Gezeh (Fig. 1). A Chinese sacrificial vessel of jade in the form of a toad was discovered belonging to the Hsia or Shang dynasties somewhere between 2205 and 1122 B. C. (Fig. 2).

In a sense, it is remarkable that the amphibian motif should be found at such early dates, for they are not common in art, even during later periods. The fish, a near but humbler relative of the frog, appears commonly through all Oriental, European and American art, ancient and modern. On the other hand, fear and sorcery were associated with the frog and toad, and apparently these decorative motifs have been used by the ancients only as charms or on sacrificial vessels. This limited use of amphibian in art may explain the comparative scarcity of such motives.

In early Egyptian times, the frog represented the Goddess Heqt (Fig. 3). Her rôle is rather vague, but it is supposed that she was associated with the idea of resurrection. She was the guardian of the mother and the newborn infant and was emblematic of renewed birth. In contrast, the Scarabaeus, or sacred beetle, symbolized duration of life on earth and in the after world and is one of the commonest motifs in ancient Egyptian art. The amulet (Fig. 1) was worn on a string by mothers as a charm (a charm in the true sense, to avert evil or insure good fortune). The frog symbol has been carried even into Christian times. Lamps, probably of Roman origin, have been found in Egypt in which the toad was used as an ornament on the top. These are covered with hard green glaze, much crackled,

[1] Sequence dates of Sir Flanders Petrie, more than 3400 B. C.

FIG. 1. A STONE AMULET FROM THE BANKS OF THE NILE UNEARTHED ABOUT 3400 B. C. (REDRAWN AFTER CHILDE).

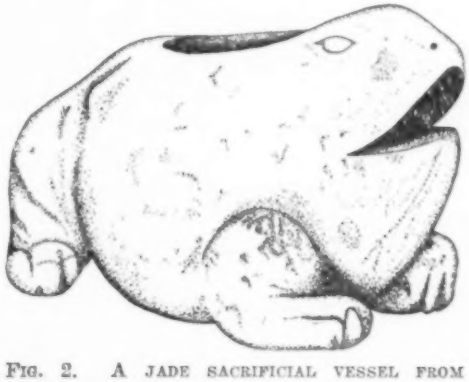


FIG. 2. A JADE SACRIFICIAL VESSEL FROM CHINA OF THE HSIA OF SHANG DYNASTY BETWEEN 2205 AND 1122 B. C. (AFTER HOBSON).

FIG. 3. THE FROG-HEADED GODDESS HEQT (AFTER BRODRICK).

and present a singular resemblance to Chinese enamel ware. Several lamps of this sort have been found in bright red pottery.

Of the Oriental races, the Chinese and Japanese have used the frog and toad most in decorative art. An astrological three-legged toad (Siam-ee) of China is supposed to represent the spirit that looks after one of the places of the moon. When houses stand in a position so as not to get the full influence of the moon, this animal is painted on the house in some conspicuous spot. The toad is also regarded as endowed with sinister qualities and has the reputation of breathing forth poisonous vapors. During the first and second centuries of the Christian era, the Chinese and Japanese artist usually figured the toad on panels or screens in floral patterns. The toad is the attribute of Taoist rishi (Gama Sennin) and is frequently figured with Gama Sennin breathing forth poisonous fumes. The most popular legend represented in Japanese art is Ono no Tōfū. Ono no Tōfū learned the lesson of patience by observing the frog and he is frequently figured gazing at a frog.

During later centuries, the frog is represented in various ways in Europe. German jewelry of the fourteenth and fifteenth century occasionally bears the images of frogs. Labarte illustrates a magical gold ring which was worn on the thumb (Fig. 4) and another ring with a toad carved in a stone set in gold. The "Newcastle mug" of the eighteenth century in England is notable, in which a frog was so placed that one drinking saw him emerge as the liquor became low. These mugs were frequently inscribed with rhymes as follows:

> Though malt and venom
> seem united
> Don't break my pot
> nor be affrighted.

It is said that a similar custom was practiced by the Chinese, and many cups have been found with frogs on the inside to frighten the drinker.

For those who follow the popular pastime of collecting antiques, a lookout for some of the Wedgwood pottery of the eighteenth century would be profitable. Catherine II of Russia ordered the great master Josiah Wedgwood to decorate a set of 1,200 dishes for use in

FIG. 4. MAGICAL RING OF THE XIV CENTURY, GERMANY (REDRAWN AFTER LABARTE).

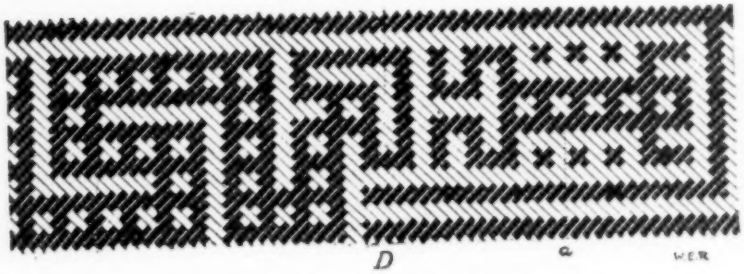


FIG. 5. A SNAKE ABOUT TO SWALLOW A FROG, FROM A BASKET OF THE GUIANA INDIANS (AFTER ROTH).

her country place, which she called "La Grenouillere" (frog's manor) because it was situated in a frog-haunted marsh land. Early in the nineteenth century, nine hundred of the original pieces of the set were rediscovered in St. Petersburg. It is believed that during the Russian Revolution every piece disappeared. The decoration is a simple purplish brown on a cream background, with a green frog in a shield. These pieces have been turning up individually in European shops.

Among the American Indians, a few rare bits of pottery, basketry, beadwork and ornaments have been discovered bearing the images of frogs. Roth, in "Animism and Folk Lore of the Guiana Indians" shows that the frog and toad have been used extensively in their arts and myths. A beautiful piece of basketry work (Fig. 5) shows a snake about to eat a frog and may represent the idea that the frog is feared and should be exterminated. He figures modern whistles and rattles, in the shape of frogs, ancient stools and benches, with grotesque figures of frogs, and glass bead aprons, bearing frog patterns. The glass bead apron, worn by the Guiana woman, bears a design, supposedly the legs of a frog, which suggests its use as a charm.

A piece of pottery, which he figures but does not discuss, apparently has a handle in the form of a frog. Fewkes, in "A Prehistoric Island Culture Area of America," illustrates an excellent polished stone amulet in the form of a frog, the workmanship of a race that perfected the polishing of stone (Fig. 6). The frog motif has been used sparingly by the Peruvians, according to Mead, but never in the conventionalized form. The Colombians represented the frog peeping over the rims of their jugs. The Cheyennes frequently figured frogs as well as turtles, otters and other aquatic animals on their drinking cups. The Hopi used the immature frog (tadpole) as a decoration on pottery (Fig. 7). Another piece of Hopi pottery shows a combination of clouds and tadpoles, possibly a graphic representation of the ancient idea that it sometimes "rains frogs." One of the most beautiful pieces of work is a jet and turquoise inlaid charm from the Pueblo Bonito (Fig. 8).

A crude picture of a toad has been found among the rock paintings of the Okanagon.

Through the courtesy of Dr. Fraus Bloom, I had the opportunity of studying several amphibian artifacts in the archeological collection at Tulane University. From the Ulua Valley of the Maya country, there is a frog whistle of pottery. The specimen has two openings at the tail end and a single opening on the front right leg on the inside. In the same collection from Mexico, there is a black stone frog, of questionable use.

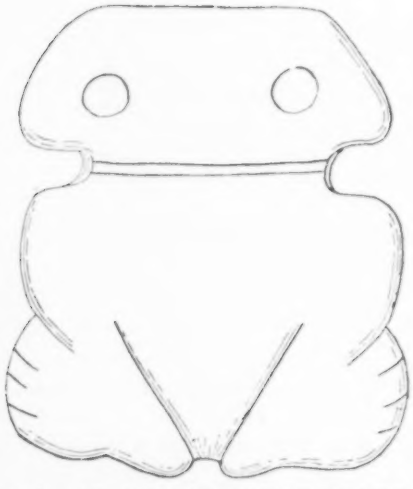


FIG. 6. AN AMULET FROM THE PREHISTORIC CULTURE OF THE WEST INDIES (AFTER FEWKES).

and a brown clay frog, three inches long, with mouth wide open and apparently used as an incense burner. Recent excavations by the Yaxchilian Expedition, conducted by the Carnegie Institution of Washington, revealed a frog on a lintel, representing the final or twenty day period.

Our first written record of frogs is probably the plagues of Egypt, supposed to have occurred about 1451 B. C., written originally in Hebrew but not translated into Greek until about 280 B. C. Aristotle (384–322 B. C.) was the first to mention the habits of these animals. In "Historia Animalum" he describes the croaking of the frogs and the feeding of the toads.

Through the fable, we get some of the earliest fragments of literature dealing with frogs and toads. Aesop (620–560 B. C.) is the author of more than four hundred fables, although it is believed that he did not commit them to writing. The elaboration and translation of these was the task of later fabulists. All contain some essence of truth concerning nature, a moral, and often profound ambiguities. We quote one from the Thomas James translation, Fable 78 Halm., "The Quack Frog." A frog, emerging from the mud of a swamp, proclaimed to all the world that he came to cure all disease. "Here!" he cried, "come and see a doctor, the proprietor of medicines such as man has never heard of before; no, not even Aesculapius himself, Jove's court-physician!" "And how," said the Fox, "dare you set up to heal others, who are not able to cure your own limping gait and blotched wrinkled skin?"

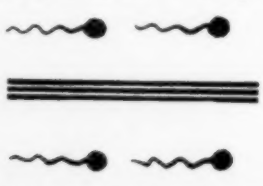


FIG. 7. TADPOLE DESIGN ON PREHISTORIC HOPI POTTERY (AFTER FEWKES).

Aristophanes (448–385 B. C.), the comic dramatist and poet of Athens, contributed "The Frogs," an attempt to distract man's mind from public affairs. It is termed a literary criticism and, like Hogarth, in art, and Addison and Steel, in literature, depicts the evils of the century.

Babrius, a Roman of the third century, has given us over 125 fables, which were probably adapted from the unwritten fables of Aesop. Another Roman, Phaedrus, of the tenth century, translated forty-two fables into Latin elegiacs. One, "The Frogs Asking for a King," has been frequently translated and quoted.

A number of Hindu fables have been preserved, written supposedly by Bidpai in Sanskrit in thirteen parts. These were lost, except a portion called the Panchatrantra, the five books. Some of these have been translated by later writers, especially a collection known as Hitopadesa, which contains several fables dealing with frogs.

In one of the Hindu myths, Agni, the fire god took refuge in the water to

escape the wrath of his enemies. He generated much heat, which caused great suffering among the frogs. The frogs became angry, and Agni cursed them so that their speech should henceforth be inarticulate.

Mikhithar Goch, an Armenian fabulist, gives us "The Big Fish and the Frogs."

From the African folk tales of Angola comes "The Frog's Saddle Horse" and from the Bornu "The Rat and the Toad."

Another Oriental myth related that a toad lived in a deep pool exhaling poisonous vapors that caused the death of numerous people that passed by. Lin-He decided to destroy the toad. Its secluded habits prevented its capture until a gold coin was dangled at the end of a hook, which proved the downfall of the toad. This myth is said to be the origin of the proverb, "The glitter of gold lures men to destruction."

A Japanese allegory, in which a snake, a toad and a snail are concerned, is known as San Sukuni, "The three cringing ones." The snake can swallow the toad, the toad can swallow the snail, but the snail in turn can destroy the snake by covering it with a slimy excretion.

Coming to more recent times, Robert Dodsley (1703–1764), an English writer, and Thomas de Irate (1750–1791), a Spanish author, have written fables resembling those of earlier fabulists, many of them concerning frogs and toads.

Famous naturalists, as Carl von Linneaeus (1707–1778) and Thomas Belt (1832–1878), have frequently written about these animals. Belt describes, in unusual language, one of the frogs in the woods of Santo Domingo, "Dressed in bright livery red, his flaming vest and blue stockings."

The only serious attempt at the frog in modern literature, scientific articles excluded, is "The Celebrated Jumping Frogs of Calaveras County," by S. L. Clemens, which was first published in a newspaper and later gained literary fame.

There are evidences that the toad and the frog were well known by the American Indians, although they were seldom used in art. We know of two tribes of the Creek Indians of Oklahoma and Alabama that had toad clans by the names Sopaktalgi and Sanakteali, respectively. The language of many tribes show a first-hand knowledge of the

FIG. 8. A BEAUTIFUL JET AND TURQUOIS INLAY FROM THE PUEBLO BONITO (AFTER WISSLER).

toad. The Mohawks have a word "Jighantak," the Cayugas a word "Naskwanaonta" and the Tuscaroras a word "Roo-nunk-shwah," to denote the toad.

Myths lend many valuable accounts of the habits and beliefs of our Indians and give us an idea of the use and estimation of the toad and frog. An Iroquoian myth is related by Converse, "How the flying squirrel won his wings, the frog lost its teeth and the woodchuck its appetite." This is a beautiful tale and equally as instructive as any of the fables or stories written for children. A squirrel had laid away his winter's supply of nuts, but they had been mysteriously disappearing. Nukdago, the chief of the squirrel tribe, decided to find out who was the thief. At midnight

he entered the forest on a tour of inspection and found a woodchuck busy carrying the nuts away as fast as he could. The next day, Nukdago continued to watch and saw a frog taking nuts and hiding them beneath some moss. Nukdago called a council of all the chiefs of the forest clans. Turning to the frog, he accused him of selfishness and theft, reminding him that he slept all winter and had no excuse to rob his neighbor. As punishment, he decreed that the frog tribe would no longer have teeth and could not eat nuts again. Turning to the woodchuck, he likewise accused him of selfishness and theft, reminding him that he too slept all winter and had no reason to rob his neighbor. As punishment, he decreed that the woodchuck tribe could no longer relish beaver or fish, but must eat grains. He commanded him to go back in disgrace and not return until the spring painted his shadow on the snow. Nukdago rewarded the squirrel by giving him wings so that he could fly back and guard his nest.

We are fortunate in having extensive accounts of the Tlingit myths by Swanton, and the Tsimshian myths by Boas. An old Tlingit myth relates how a woman lived with a frog. This story is not unusual, as Indian myths are replete with accounts of the relationship of woman in matrimonial affiliations with various animals. No doubt the frog represented a very low form of degradation. A Tsimshian myth tells of a boy that caught a great frog. A chief's nephew was a poor orphan. One day a white bear was heard near the village and the chief promised his daughter to him who killed the beast. The orphan boy killed it, but other boys claimed the honor. The orphan boy's arrow was found, and the chief, being very much ashamed, left his nephew, daughter and grandmother. The orphan went to a pond and shouted and a great frog emerged and pursued him. He made a big trap and caught the frog. He skinned the frog and with its charm was able to catch very many fish. A princess learned of this and married him. About this time, the chief's people were starving, and he sent a slave to find out whether his nephew, daughter and grandmother were still alive. The boy sent back food for his uncle. He continued to catch fish, which he sold to buy slaves and eventually he became a chief. This continued, but he was unable to throw off his frog blanket and he stayed in the pond where he provided food for his family.

The Indians used frogs chiefly in sorcery, although a few tribes used them as food. Boas, in treating of the ethnology of the Kwakiutl, states that the feet of a toad, together with four arms of an octopus and the tip of the tail of a snake, were used as a charm at childbirth. The Kwakiutls had their frog dances, frog songs and frog whistles. The Creek Indians also had a frog dance known as Akatalaswa obanga. The Akatalaswa was a very small but a very noisy frog. Roth, in "Animism and Folk Lore of the Guiana Indians," dwells upon the uses of the frog and toad for augury. They foretold rain, brought fire and wood and assisted in hunting. They were used in ordeals and as charms. Hunting and music were taught by them and they were eaten as food. Among the numerous string tricks, used in ceremonials, one was called the frog. The Salishan tribes of the Western Plains believed that killing frogs brought rain. Their women used the toad to poison their husbands. A large black toad was hung to the branches of a tree by the legs. The mouth was propped open by means of a stick and the juices allowed to fall into a vessel. Sometimes the toad was placed on a flat rock and pounded with a second rock until the toad was dead. Then the juices of the body were collected. In either case the poison was

placed on the food to be eaten. The Winnebago, according to Radin, used the toad only for poison medicine.

Recent civilizations have given evidence of their fear, dislike or familiarity of the frog through place names. We have: Froges, France; Frog Lake and Frog Portage, Canada; Frogmere, Louisiana; Frogner, Minnesota; Frogville, Oklahoma, and Toadvine, Alabama.

The frog and toad have likewise been immortalized in plants and animals. They serve as convenient handles or common names for numerous plants as: frog bit, a small rootless plant with floating leaves belonging to the family *Hydrocharitaceae;* frog orchis, Habenaria of England, a relative of our beautiful and somewhat rare purple fringed orchis, also the European Oncidium, so-called frog orchis because its lip bears at its base the figure of a frog, couchant; frog cheese, one of many large puff-balls or mushrooms; frog flower and frog-wort, common names for the buttercup; frog fruit, a species of Lippia; frog grass, a species of glasswort, Salicornia; frog-lily, a common yellow lily. Nymphaea; toad lily, an ornamental of Japan of the genus Tricytis; toad orchis, a species of Megaclinium from Sierra Leono; toad pipe, a species of horse tail, Equisetum; toad rush, one of the Juncaceae; toadflax, a weed of the genus Linaria; bastard toadflax, a species of the genus Comandra; toad flower, a species of Stapelia; toadstool, one of the many capped mushrooms; toad mouth, a species of Antirrhinum, also called lion's mouth.

Among the animals we find common names as: frog mouth, an Australian bird, Podargus, so named from its cry; the fishing frog, Lophius, one of the bottom-feeding fishes of the coast of Europe and Western North America; frog hopper, a group of insects also known as spittle insects of the family *Fulgoridae;* frog crab, one of the Raninoid crabs; toad bug, several true bugs of the family *Gelastocoridae;* toad fish, numerous tropical fish, especially of the genus *Batrachus;* toad head, a local name for the golden plover.

The words frog and toad are also used in the English language to denote other things or ideas, as the frog of a railway or toady from toadied, meaning to frown upon.

The frog and the toad have inspired a few poets. Geoffroy Chaucer mentions the frog briefly in two lines:

> In places sawe I welles there,
> In whyeh there no frogges were.

John Burroughs' reference to the frog is scarcely more pleasing:

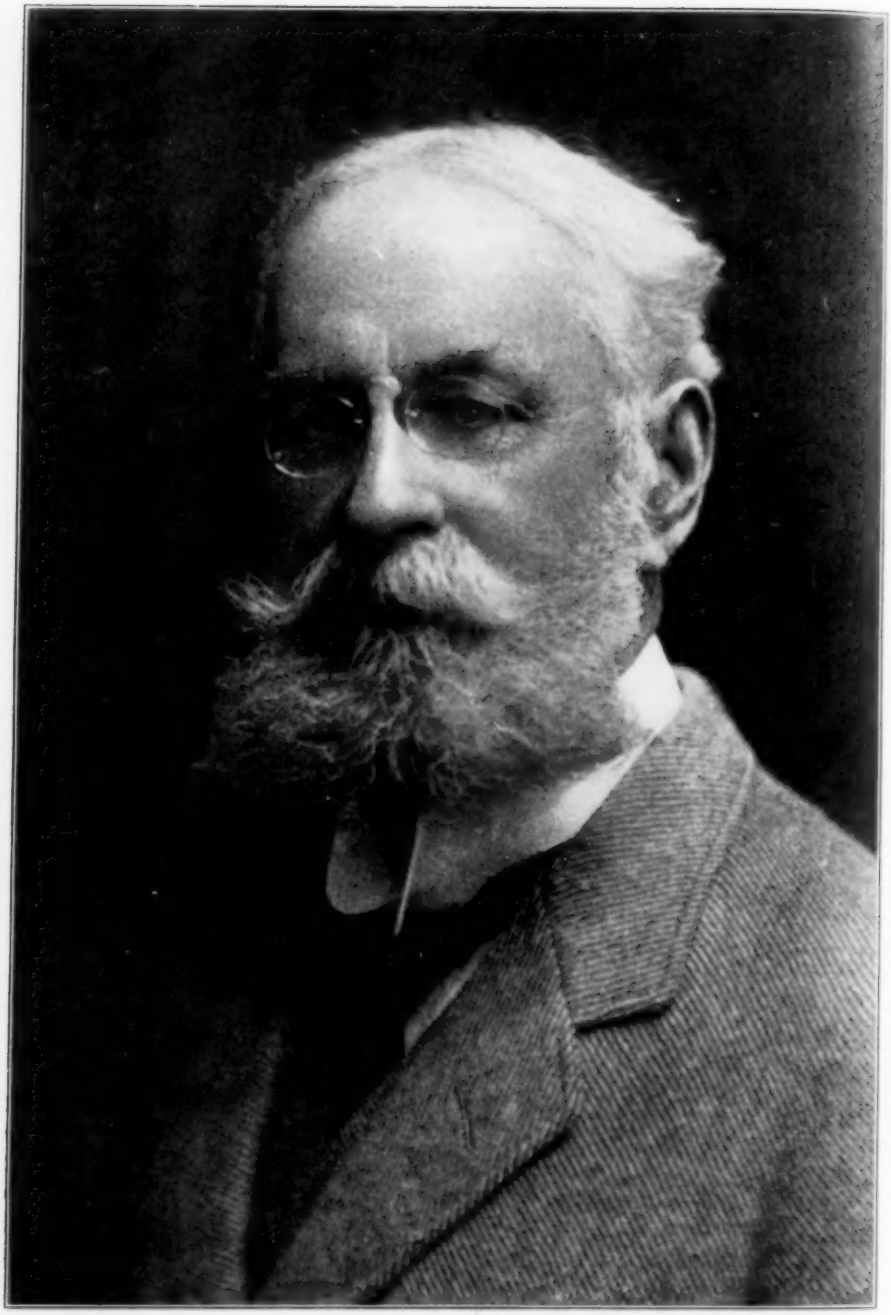
> I believe a leaf of grass is no less than
> the journey-work of the stars,
> And the pismere is equally perfect and a grain
> of sand and the eggs of the wren
> And the tree toad is chef-d'oeuvre
> for the highest.

From John Greenleaf Whittier's "Barefoot Boy" comes the following pleasing lines:

> While for music came the play
> of the pied frog's orchestra
> And to light the noisy choir
> Lit the fly the lamps of fire.

A number of other poets have written about the toad and the frog, especially: Anne Bradstreet, "The Four Seasons of the Year"; Juliana Horatia Ewing, "A Friend of the Garden," concerning the toad; Thomas Westwood, "Tourncoats," and one by an English author, Hilaire Belloc. In closing we quote from James Whitcomb Riley:

> Who am I but The Frog.—The Frog!
> My realm is the dark bayou,
> And my throne is the muddy and moss-grown
> log
> That the poison ivy clings to—
> And the black snakes slide in the shining tide
> Where the ghost of the moon looks blue.



GENERAL A. W. GREELY

THE DISTINGUISHED ARCTIC EXPLORER AND METEOROLOGIST WHO CELEBRATES HIS EIGHTY-EIGHTH BIRTHDAY ON MARCH 27.

THE PROGRESS OF SCIENCE

AWARD OF THE AGASSIZ MEDAL TO DR. BIGELOW

PROFESSOR HENRY BRYANT BIGELOW, who received the Agassiz Oceanographic Medal at the November meeting of the National Academy of Sciences held at Yale University, was born in Boston on October 3, 1879. He was trained at the Harvard Laboratories and took his doctor's degree there in 1906. His publications, all of which refer in one way or another to oceanographic subjects, total over half a hundred.

His first paper, entitled "Birds of the Northeast Coast of Labrador," appeared in 1902. In the winter of 1901–02, he accompanied Mr. Alexander Agassiz on a voyage to the Maldive Islands, and in 1904 he published his report on the jelly-fishes of this expedition. In 1904–05, he again accompanied Mr. Agassiz this time on the expedition to the Eastern Tropical Pacific and in 1909, he published his very extensive report on the Medusae of this expedition and two years later the report on the Siphonophores.

Meanwhile, through the advice of Sir John Murray, he began to take an active interest in the oceanography of the New England waters. In 1908, the U. S. Fisheries schooner, *Grampus* was sent under his general management on an expedition to the Gulf Stream, a report of which he published in 1909. This initiated his extensive series of studies of the waters of the Gulf of Maine. These were made possible largely through cooperation with the U. S. Bureau of Fisheries, which repeatedly put at his disposal the use of the *Grampus*. In 1914, he reported on the oceanography of this region, and in the same year he published an account of the plankton of Massachusetts Bay. This was followed by a report on the oceanography and plankton of the waters between Nova Scotia and Chesapeake Bay. In 1917 an additional report was made on the region from Cape Cod to Halifax. Then followed the three extensive contributions of 1926 and 1927 covering the plankton of the Gulf of Maine, its dynamic oceanography and its physical oceanography. Meanwhile, in conjunction with William Welsh, he had issued his important volume on the fishes of this region. The proposal for an ice patrol as a means of greater security for shipping in the North Atlantic had been taken up by the U. S. Government, and, in association with Lieutenant Smith, Bigelow worked out much of the details of this organization. A report on this subject was published in 1929.

As work progressed the conviction grew upon him that an oceanographic institution should be started on the Atlantic coast of the United States, and he reported on this subject to the National Academy of Sciences in 1930. The material of this report was finally issued in the form of a volume entitled "Oceanography, its Scope, Problems, and Economic Importance." This volume was published in 1931 and was distributed to the members of the academy. As a result of these activities the Woods Hole Oceanographic Institution was organized and a building to house it was erected near the Marine Biological Laboratory at Woods Hole and opened this past summer. Dr. Bigelow has served as its first director.

Dr. Bigelow during his student days was not reputed as a diligent scholar. In fact, he was informed by one of his old teachers that he would do well to withdraw from the Harvard Laboratories, for he was judged both negligent

DR. ANNIE JUMP CANNON

and idle. Bigelow, however, had his own way of working and has demonstrated that these ways lead to affective results. He is soaked with the atmosphere of the sea and will unquestionably devote himself to the end of his days to the promotion of oceanography.

As a life-long associate of Alexander Agassiz and as a close personal friend of Sir John Murray, his appointment as an Agassiz medalist is especially appropriate, but the real ground for the presentation of the Agassiz Medal to him is his position as one of the first oceanographers of the world.

G. H. P.

THE AWARD OF THE DRAPER MEDAL TO DR. ANNIE J. CANNON

One of the most marked distinctions in the American astronomical world was recently conferred on Dr. Annie Jump Cannon, of the Harvard College Observatory at a meeting of the National Academy of Sciences in New Haven last November, when she was awarded the Henry Draper Medal for outstanding achievement in astronomical physics.

Perhaps no single item of information about the stars finds its way into so many different aspects of astronomical research as does the knowledge of their spectra. In problems of distance, brightness, temperature, size, motions, distribution in space, variation, and physical structure, the spectrum of a star plays a revealing rôle. And it is to Miss Cannon's untiring work during the past thirty years that much of the present knowledge of stellar spectra owes its existence.

Dr. Cannon, who was born in Dover, Delaware, graduated from Wellesley College. She has received honorary degrees from Wellesley, from Groningen and from Oxford, where she was the first woman to receive the honorary degree of Doctor of Science.

The work which was, in the course of time, to provide such a powerful instrument for astronomers in their analysis of stellar structure, was begun at the instigation of Professor Pickering, then director of the Harvard Observatory. A considerable amount of work had been done on classifying spectra on the Harvard photographs. Miss Cannon reorganized the classification, and so effective was the result that it has, with few additions, remained ever since the internationally accepted basis for stellar analysis.

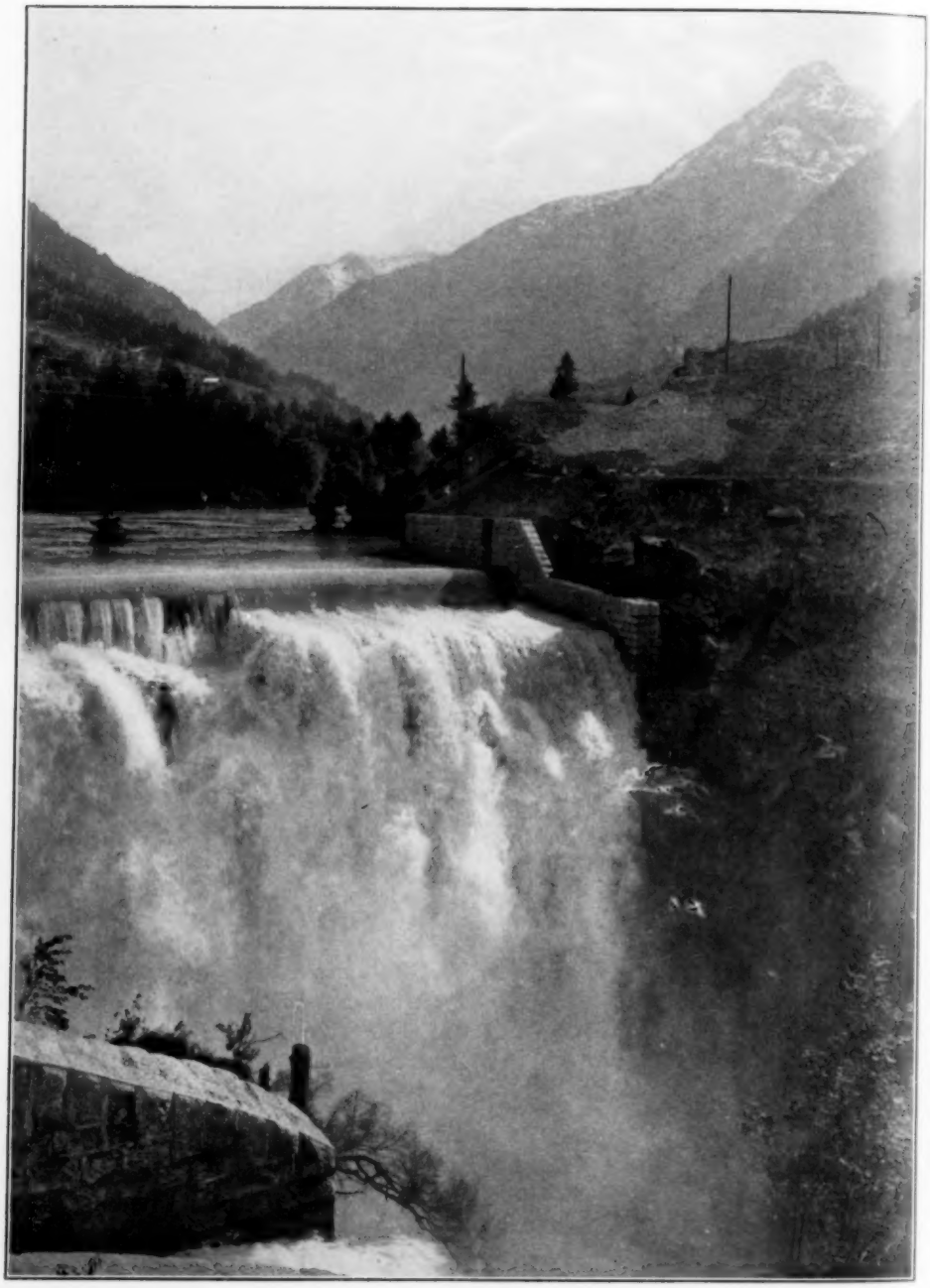
The most distinguishing characteristic of Miss Cannon's classification of stars is the fact that it reveals a continuous sequence throughout the entire gamut of stellar types. This relationship exhibited among all classes of stars shows the possibility of an evolutionary progress, and offers much in the way of explaining the history and development of the stars.

During a period of fifteen years Miss Cannon devoted her energies to analyzing and classifying 225,000 stars, over the whole sky. Her results were published in a series of nine volumes of the Harvard Observatory Annals, in which are given not only the stars' spectra, but their positions and magnitudes as well.

Since completion of this catalogue, Miss Cannon has demonstrated her remarkable energy and enthusiasm by undertaking an extension to the catalogue, comprising stars of magnitudes fainter than those earlier classified. This extension already contains the classification of over a hundred thousand stars.

The catalogue is itself a memorial to Henry Draper. It is peculiarly fitting that the valuable work of Dr. Cannon should be acknowledged by the conferring on her of the Henry Draper Medal.

J. M.



THE FALL OF REUSS

FROM THE PFAFFENSPRUNG, ABOUT 900 FEET ABOVE THE POWER WORKS AT AMSTEG.

DEVELOPMENT OF WATER POWER IN SWITZERLAND

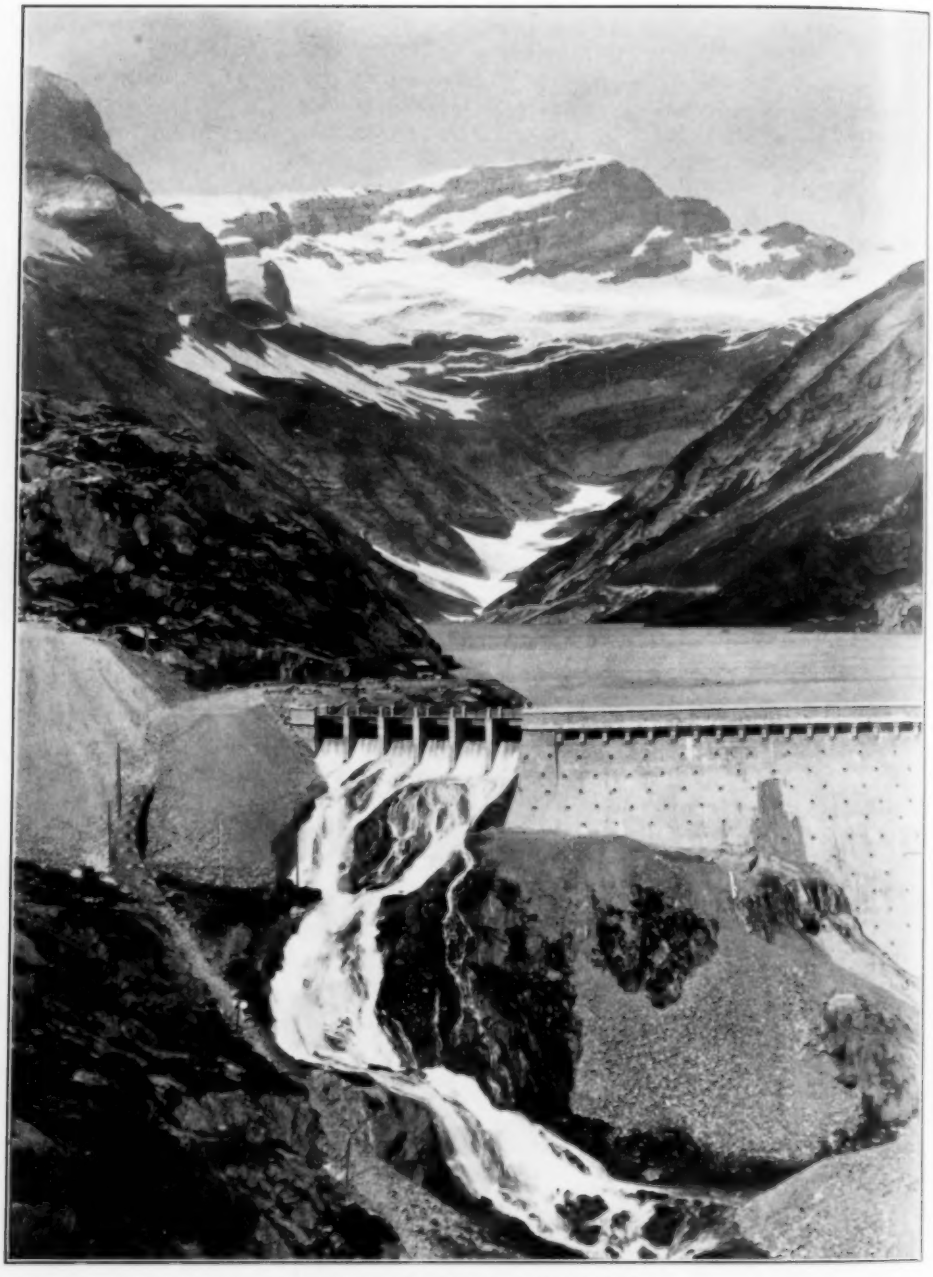
SWITZERLAND, land of scenic grandeur, high peaks, rushing mountain torrents and accumulating glaciers, early turned a far-seeing business eye on natural assets for industrial purposes. Centrally located without a seaport, knit in by rugged mountains, without adequate farming facilities, the country was forced to turn its attention to the electrical energy hoarded in water power for economic development.

In the course of the last century the products of the soil became inadequate to provide for the maintenance of an ever-increasing population. Coal was an expensive import, as there are no coal mines in Switzerland. Her rivers and water falls are, however, a great natural wealth and their exploitation for power has become a vital economic factor ever since electrotechnical methods made the utilization of energy possible at a great distance. Not only is electric energy now used almost entirely for the railways and for other industrial and motor purposes, but also 90 per cent. of the Swiss people have electric lighting and 98 per cent. of the municipalities are branched on to an electric system.

The topography of Switzerland facilitates the use of water as power. The total surface measures only about 16,000 square miles, yet in this small area there are tremendous differences of altitude. The highest point, Dufourspitze of Monte Rosa in the Alps, is 15,217 feet above sea-level, while the lowest is 581 feet on the Lago Maggiore. The declivities are consequently very pronounced and the river, stream and torrent beds are abrupt. It is difficult to estimate the available water power of a country, but it has been approximated that Switzerland has available four million horsepower. The United States, with an area almost one hundred and ninety times that of Switzerland, has available only fifty-five million horsepower, or about fourteen times that of Switzerland.

Judging from the above, the prevalent conditions would appear to be favorable and simple. Switzerland's hydrologic régime, however, has a peculiarity which has a strong influence on the country's hydroelectric economy and determines the course to be pursued for the exploitation of water power. Although 60 per cent. of the precipitations occur during the five winter months (November to March) and only 40 per cent. during the seven summer months (April to October), rivers and streams have high waters in summer and low waters in winter. This curious condition results from the high altitude of the Swiss territory, which averages 4,429 feet above sea-level. The Alps are covered with snow and ice throughout the year. During the summer months a portion of the glaciers melts, whereas in winter and autumn precipitations in these regions generally take place in the form of snow and remain stationary. The energy which, in winter, is produced directly without compensation by means of accumulation, constitutes but one third of that obtained during the summer.

Exactly the opposite takes place as regards consumption and demand throughout the year. Demand is greater in winter than in summer for lighting and heating. Although this difference is not as pronounced to-day as it was formerly when electricity was used almost exclusively for lighting purposes, maximum consumption of electric current during a winter day still comes to 120 per cent. of the average daily consumption throughout the year; that for a summer day represents about 80 per cent.



THE BARBERINE RESERVOIR

NEAR CHÂTELARD IN THE VALAIS, A BEAUTIFUL ALPINE RESORT REACHED BY THE ELECTRIC RAILWAY CONNECTING MARTIGNY WITH CHAMONIX.

An economical exploitation of the natural energy of Swiss water-courses is only possible by adopting a measure to compensate the divergency between output and consumption.

Among the various methods advocated, such as the creation of industries which do not require electricity throughout the year, the construction of thermic plants or the exportation of electric current in summer, the system of hydraulic accumulation of energy during the summer, when output exceeds consumption, is the most economical and popular in Switzerland.

Accumulation is effectuated by means of dams for the retention of the water during the summer. This method is expensive and the many constructions are necessary. To create artificial basins (or to increase the capacity of lakes already in existence) requires the flooding of vast areas. It is, therefore, necessary to select sites where accumulation is possible over as small and inexpensive a territory as possible, preferably waste or uncultivated land; and economy further demands that the accumulated water yield the greatest possible amount of energy per unit ($meter^3$) in order to diminish the volume of water required per unit of energy (kilowatt), offering thereby a good return for the capital invested in the enterprise. This result is obtained by the construction of plants having basins for accumulation situated on rivers or mountain torrents with powerful falls. The energy produced by a waterfall is proportionate, on one hand, to the volume of water flowing per second, and, on the other, to the height of the fall. The greater the latter, the smaller the volume of water necessary to furnish a given amount of energy.

LAKE GELMER IN THE BERNESE OBERLAND

FORMS PART OF THE HUGE GRIMSEL POWER WORKS WHICH ARE NOW UNDER CONSTRUCTION.

THE RITOM LAKE

SUPPLIES A PORTION OF THE WATER-POWER FOR THE ELECTRIFIED GOTHARD RAILWAY. A FUNICULAR RAILWAY CONNECTS THE POWER STATION AT PIOTTA, SOUTH OF THE GREAT TUNNEL, WITH THIS LAKE.

In Switzerland, electric generating plants are constructed, consequently, in the vicinity of the Alps, where small torrents with powerful falls produce large quantities of electric energy with comparatively little water, this condition reduces the dimensions of basins and dams required and at the same time at such altitudes land is less expensive than elsewhere.

This seasonal variation in output and consumption contributed towards the creation of groups of combined plants. While some plants, situated on the lower portions of rivers or streams, utilize in summer great masses of water with gentle falls to produce considerable quantities of energy, others, in the higher Alpine regions, fill their accumulation basins in preparation for the low-water period. As long as the former are able to cover the demand, the latter are not put into action. At the beginning of winter with its lower water level and increased consumption, these plants are then called upon. The waters accumulated throughout the summer months are slowly utilized, whereas the plants at lower altitudes produce considerably less energy.

Considered from an economic and financial point of view, these groups of power plants are not all organized on the same basis. The Swiss Confederation owns the groups connected with the electric traction of the state railways only. A small number are owned by the cantons or municipalities. Others are run by private companies. The most important groups, however, such as the "Forces Motrices Bernoises," the "Nord-Est Suisse," "l'Energie Ouest

Suisse" and others are owned by "mixed companies," of which the larger portion of the stock is in the hands of the cantons or municipalities. In this case private capital cooperates with public economy in a combination which has given excellent results in the majority of cases, according to Professor C. Andreae, Engineer E.P.F., former rector of the Federal School of Technology at Zurich.

The largest power plant for accumulation in Europe is now under construction on the river Aare at the Grimsel Pass, where much attention is being paid to the architectural possibilities of the plant. Already there are approximately 160 plants equipped with installations capable of producing over 1,000 h.p. and the total capacity of generating stations, at the end of 1927, had increased 151 per cent. over 1914. Now Switzerland, utilizing 1.6 million of the approximate four millions of horsepower available, has come to the place where only Great Britain and Belgium have a relatively greater industrial population.

RUBBER FROM ROCKS

A FEW weeks ago du Pont chemists startled the scientific world by announcing the first commercially successful artificial rubber. While the press promptly reported the achievement, the somewhat meager character of the reports has led many people to view the announcement with skepticism. Such an attitude, however, is not justified. In reality, one of the fondest dreams of the synthetic chemist has at last been realized, and a man-made product, starting from mineral materials totally unrelated to natural rubber, will soon be available at a price which will allow it to compete for certain specialized uses even at the present low price of the natural product.

Numberless attempts have been made in the past to synthesize rubber or to produce some substitute for it. "Cut and try" methods resulted in weird combinations of gelatine, glue, drying oils, ground cork, fish eggs and dung. While some of these messes had resilient and spongy properties, none of them approached the qualities of long wear, elasticity and strength manifest in natural rubber. On the other hand, more scientific methods of approach slowly unraveled the physical and chemical secrets of rubber. Scientists definitely established that the basic constituent of rubber is the simple compound isoprene. Still they could not commercially synthesize rubber. The preparation of isoprene itself is difficult and expensive, and the step from this clear, water-white liquid to rubber is one so difficult that, after years of research, it can be accomplished only very imperfectly. Although Germany, during the last months of the war, used a similar process to produce an inferior material that could be substituted for rubber, necessity in this case dictated disregard of cost and the acceptance of a low-grade material. However, following the war, when the price of raw rubber soared, these processes were not even considered as possible sources of supply.

Despite these failures, when Father Nieuwland, of the University of Notre Dame, several years ago obtained from acetylene traces of a material remotely related to the basic constituent of rubber, du Pont chemists saw in his discovery a possibility of obtaining the long-sought goal. Cooperative study of the problem was arranged and, as a result of this joint enterprise, lasting over several years of disappointing failures, the problem was finally unexpectedly solved. This work has been carried on with the utmost secrecy, and the announcement that synthetic rubber, differ-

ing from the natural product in composition, had not only been discovered but was actually being made on a sizable scale came like a bombshell.

Naturally the details of the process are still secret, but we are able to say that the basic materials are limestone, coke and ordinary salt. Thus the new product is entirely independent of living matter for any portion of its source of supply, and is made from cheap and abundant mineral raw materials.

Economically, the du Pont chemists believe that their product will not as yet serve as a substitute for rubber in all uses, but though it is more expensive than rubber at present prices, it is far cheaper than rubber has often been. The important point is that for many uses the new product is superior to rubber. For example, samples soaked in gasoline for days did not swell or deteriorate unduly. Another important advantage is that the new material cures without the addition of sulfur or other foreign bodies to aid in vulcanization. While the investigators conservatively admit that in some respects their material is inferior to the natural product, others minimize these differences. The new material, called "Duprene," is identical with rubber in respect to appearance, feel and stretch, but differs from it in that it has none of the characteristic rubber odor.

While it is of course too early to say with any degree of certainty what effect this new synthetic rubber will have on the production of the natural product, it may be pointed out that the raw materials are cheap and available in many parts of the world. In particular, the United States is freed by it from dependence on outside sources for its rubber. While admittedly the new product is now more expensive than natural rubber, it should be remembered that the process for making it is in its infancy, and with refinements, the price will undoubtedly become more and more competitive. Furthermore, the discovery of synthetic alizarine and of synthetic indigo years ago led ultimately to the practical abandonment of the growing of the madder plant and of natural indigo. Is a similar fate in store for the growing of natural rubber?

GUSTAVUS J. ESSELEN